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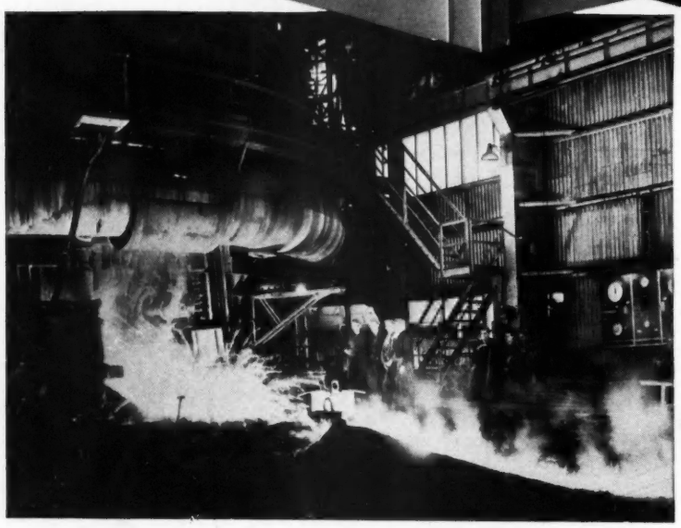

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ENGINEERING

An Illustrated Weekly Journal

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AFTER GENEVA

DURING the International Conference on the Peaceful Uses of Atomic Energy in Geneva, Sir George Thomson was asked his views on the possibility of applying the fusion or H-bomb process to the generation of electric power. He replied: "It will come in the end; it is bound to come. The ingenuity of engineers is so great that any proposition put to them which does not deny some physical principle will be solved in a relatively short time; in this case perhaps a generation."

Nevertheless, whatever direction nuclear development takes, the problems engineers will be called upon to solve will be formidable. In a sense the engineer has had to jump aboard a moving vehicle; security has prevented him from accumulating knowledge as this new technology has gathered speed. But now that the Geneva Conference has made available much of the necessary information, he can make good his disadvantage. To that end, we have endeavoured in covering the Conference to publish articles which will not only interest the specialist, but will also—with the help of cross-references to other articles in ENGINEERING, explanations in parenthesis, and the glossary given last week—be intelligible to the layman.

What then will be the engineer's part in the application of atomic energy? How will this almost unlimited source of power affect engineering industry.

Though the technology may be complex, the nuclear reactor itself is a fundamentally simple idea. It is in fact a furnace in which a material disintegrates under neutron bombardment and gives up energy which appears as heat. Each disintegrating atom also emits several neutrons which continue the process. In some cases the process is controlled by inserting or withdrawing rods of a material which absorbs neutrons. A fusion reactor, of course, would be basically different. Of the 70 or 80 possible reactor designs, only some seven or eight seem promising for power production.

It will be the engineer's task to evolve—within the limits set by materials and economics—practical working installations from the basic reactor designs. He will be required to solve such problems as the linking of expensive corrosion-resistant metals to more workaday ones in such a way that the joint can withstand differential expansion (this difficulty has been tackled by Tube Investments Limited with the aid of a long spliced welded joint). He will be called upon to deal with high temperatures and pressures and corrosive atmospheres, the disposal of fission products and operator safety, the handling of liquid metals and efficient heat exchange. Many of these problems, however, he will have met before, and in any case the Atomic Energy Research Establishment at Harwell has already assembled a wealth of experience.

Few branches of engineering will be excluded from taking part in this development; the civil engineer will be responsible for the vast structures involved, the mechanical engineer for converting the heat into electrical power and for ancillary plant, and the electrical engineer for electrical machinery and distribution. And the result of their work will be abundant power for industry.

This new power has come at a time when it is most needed; not only are other fuels running short but industry will be needing greater and greater quantities. Automation promises a new industrial revolution, but if power were to become prohibitively expensive automatic transfer machines would prove poor competitors with human labour. Atomic energy also offers other prospects. The transportable reactor may solve the problem of power supplies for remote sites; the use of radioactive isotopes and tracer techniques may permit machine processes to be better understood and agriculture to be revolutionised; smaller territories might become self-supporting. Energy has been equated to manpower, and atomic energy in combination with automation may even help to solve the inflation problem, since one of the causes of inflation is "too many jobs chasing too few men."

More generally, we must learn a new approach to technological progress. The forthright questions and frank replies of the Geneva Conference have undermined the practice of trade and national secrets, and as Dr. Homi J. Bhabha said in his closing Presidential address: "Knowledge once given cannot be taken back." He also drew attention to the consistency of results produced independently by different nations; this suggests that methods of avoiding the duplication of research should be devised together with a system of reward for research not based on concealment within one organisation or country.

But possibly the conclusion arising from the development of nuclear energy which most merits consideration is the change in industrial structure which is likely to occur. Once, energy was the ultimate limit of production; in the future it is likely to be some other factor—probably the supply of materials. Thus it may soon be necessary to consider very seriously the problem of conserving materials—unless of course the nuclear physicist shows us how to convert the materials we have in abundance into the ones we need.

Weekly Survey

Cover Picture. *Naval squadrons of Gannet anti-submarine aircraft are being formed regularly and to plan. Recently the first Gannet squadron afloat embarked in H.M.S. Eagle. Other squadrons are ashore, working up in readiness for embarkation on other carriers later this year. A three-seat "search and strike" aircraft, the Gannet is powered by a propeller-turbine, and can carry a variety of weapons or "sonobuoys" under the wings.*

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BOOSTING BRITISH INDUSTRY

The scheme sponsored by the Federation of British Industry for providing practical training in Britain for young graduate engineers from the developing countries overseas is growing apace. The annual report, *F.B.I. Overseas Scholarships*, just issued, shows that since the scheme began in 1950, 80 scholarships have been awarded, 64 scholars have actually arrived in the United Kingdom and 23 have completed their training and returned home. It is hoped that within a short time that 150 scholarships will be awarded each year, and 107 are in fact being offered for award in 1956.

The scholarships, providing training for two years in British engineering works, are at once a form of technical assistance to the countries and also a means of familiarising their future industrial leaders with British equipment and methods, so that they may be predisposed to "buy British." In the words of the report they represent "a long-term investment in our future exports." A new scholarship, to be administered jointly by the F.B.I. and the British Council, is to be launched for young university professors from Latin America. It will provide for periods of 20 months here, equally divided between an engineering works and a university, with the object of encouraging these professors to arouse the interest of their students in British engineering methods when they return home.

The report notes that 73 firms or organisations are as yet participating in the scheme. In a foreword, Sir Arthur Fleming, C.B.E., D. Eng., chairman of the scholarships committee, writes: "Many engineering companies have not yet opened their doors to overseas trainees, although they could readily provide excellent training facilities, either alone or in association with others . . . Companies engaged in export are the most direct benificiaries of the scheme, but all concerned with engineering will benefit from it in the long run." A greater response by firms will be one way of combating the loss of traditional markets such as is reported in this week's note "India goes elsewhere for locomotives."

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COAL AND INFLATION

The last increase in coal prices has produced a stout protest from the Engineering Industries Association, who view with alarm the prospect of further price increases or severe shortage. They point out, quite rightly, that the National Coal Board's policy is long term, to raise output by the sinking of new pits and by the continued investment in modern machinery. Meanwhile, the industry reveal themselves unable to recruit labour at a rate adequate to offset natural wastage. "There is little evidence," E.I.A. argue, "that the recommendations of the Fleck Committee are being implemented with the necessary vigour." This is the keynote of the statement—that a sense of urgency about the situation is lacking, and both the N.C.B. and the Government come in for criticism.

The E.I.A. formulated a "nine-point plan," which includes some emergency measures—such as a suggested subsidy for imported coal, and a rapid reduction of exports—and a plea for more determination in dealing with the industry's major problems of labour recruitment and productivity. They consider the situation sufficiently critical to warrant the introduction of foreign labour and one suspects that the N.C.B. heartily agree; the Yorkshire miners, on the other hand, recently made plain that they hold other views, and so long as the lodges refuse to allow foreigners to work it is difficult to force their hand. Similarly, the urging of recruitment campaigns will meet no opposition: the miners themselves want better and bigger ones and the suggestion of improved housing schemes and assistance in removal to new coalfields has their full support. The yawning gap in the N.C.B.'s armoury has long been on the side of public relations and the E.I.A. are on strong ground when they ask for better leadership and better personal contacts throughout the industry. But this is a slow process, and the growing clamour for better pay shows that leadership and good management is not all that may be required.

Basically, it might be said that in conditions of full or overfull employment, coal mining does not appeal. If we hope, therefore, to maintain our prosperity (when some degree of inflation is likely to remain) the country must see to it that (1) coalmining does appeal or (2) that the dependence on coal is lessened, or both. Atomic power promises much, but not quickly enough to affect the next five years; conversion to oil will also be a gradual process. The N.C.B. have said that the benefits of post-war investment schemes, particularly in the newer coalfields, are still to be felt. It would seem that, in the short term, economy is the most effective way of avoiding a crisis. The 60 per cent. tax allowance on fuel-saving equipment suggested by E.I.A. would certainly help to promote it.

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THE HEALTH OF GERMAN INDUSTRY

When Dr. Reuter, managing director of Demag, addressed his company's shareholders at their annual meeting his words were for a far wider audience. He spoke with all the confidence and authority of the head of one of Western Germany's industrial giants, with assets in excess of £28 million and supplying "machinery and capital goods of all kinds" to a wide range of industries, including mining, iron and steel, metal processing, engineering, foundries, power stations, transport undertakings, chemicals, ports and shipyards, civil engineering, etc. Dr. Reuter commented on the performance of German engineering, vigorously slated those who say that German exports are subsidised or that German manufacturers are privileged by being able to offer long-term credit and sounded a clarion call for convertibility—"the only way to restore freedom in world trade."

German engineering in 1954 remained "in a phase of expansion—in production, intake of orders and exports" but derived its momentum from "the home market rather than from the export trade." The proportion of output exported fell from 38 per cent. in 1953 to 33 per cent., and accounted for 19·5 per cent. of total German exports, 2 per cent. less than the previous year. Yet engineering exports increased by 8½ per cent. to £370 million and engineering remained the largest manufacturing industry.

Dr. Reuter refers to a report of the Credit Insurance Association of Great Britain (Weekly Survey, November 12, 1954) in support of his claim that there are no German export subsidies. He quotes figures issued by Ausfuhr-Kredit A.G. (A.K.A.)—"practically the only source of export finance"—which had granted at December 31, 1954, credits totalling DM. 665 million (about £67 million) of which less than 55 per cent. was on terms for more than two years and only "a very small percentage" covered 4 or 5 years. Dr. Reuter then suggests some form of international agreement on credit terms that are "both reasonable from the suppliers' point of view and yet acceptable to customers."

According to Dr. Reuter, German industry is sorely in need of capital investment, especially the steel industry which cannot produce at competitive prices. The new capital investment needed in Germany for manufacturing industry is put at between £170 million and £212 million per annum. Iron and steel, the black sheep, seems to be licking itself clean with commendable energy: Demag's intake of orders in 1954 was 50 per cent. higher than the previous year, and 60 per cent. of the total (including exports) consisted of orders from iron and steel makers. But Dr. Reuter hopes "... that a more effective policy of depreciation allowances will be adopted by the revenue authorities in order to enable the industry to meet its capital needs."

Some of Dr. Reuter's address is special pleading, though much sounds good sense; it is clear warning to this country that German engineering has set its sights high and is expanding fast "in a free market economy." It could, however, be freedom to inflation.

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INDIA GOES ELSEWHERE FOR LOCOMOTIVES

The largest order to be placed by India for locomotives, 431 steam locomotives valued at £6·8 million, was split between Germany (176), Japan (125), Hungary (40), Austria (50) and Czechoslovakia (40). British tenders were 30 per cent. higher than the lowest bid submitted but 35 per cent. above the final prices. The British builders consider that the prices quoted in the successful tenders are below production costs, and conclude that the companies concerned must be receiving some form of subsidy. They are certainly the keenest quoted for steam locomotives since the war and it is difficult not to come to the same conclusion.

The lowest bid was submitted by the Hungarian State Works, for the YL type—a metre gauge 2-6-2 locomotive—at a unit price of £13,000 c.i.f., which was £400 less than the price quoted by Hitachi (Japan) and £480 less than that quoted by Henschel (Kassell, Germany). The accepted prices for the large YG locomotive—a 2-8-2 engine—were the same for all successful bidders, £18,100 f.o.b. This compares with £21,000 obtained by Krauss Maffei of München-Allach four years ago, when the Indians agreed to an escalator clause in the contract. Krauss Maffei refused to accept orders for the YG locomotives on the ground that prices were such that "we did not feel justified in accepting them in view of the likely losses," and accepted the order for 25 YL locomotives "only because we feel obliged to continue to fulfil our obligations under the technical aid contracts we have with the Tata works."

British output of steam locomotives for export during the first quarter of this year was about one-third less than in the first quarter of 1954 and there is little doubt that the industry would have welcomed at least some of the orders placed by India. But few valid arguments can be advanced in favour of accepting orders at a loss. The Indian market has been a great disappointment to British builders since the war, particularly in view of the considerable technical assistance granted by them—through the Locomotive Manufacturers Association—in establishing a locomotive building industry in India.

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JAPAN ELECTED INTO G.A.T.T.

The election of Japan as contracting party to the General Agreement on Tariffs and Trade by the requisite two-thirds majority at the organisation's recent meeting in Geneva came as no surprise, but is yet an additional problem for this country and the British Commonwealth. How big a problem will be revealed at the meeting next January of 25 nations at Geneva (under the auspices of G.A.T.T.) to discuss tariffs. The time of the conference was dictated by the terms of the new Reciprocal Trade Agreement Acts which give the U.S. President authority to cut tariffs by 15 per cent. over three years in three equal annual slices. Unless the authority is used within each fiscal year, it lapses at the end of it (June 30). For some time now there

has been pressure on this country and the Commonwealth to reduce protective tariffs and particularly the preferential structure which protects trade within the Commonwealth from outside competition. A contracting party to G.A.T.T. has the right to "most favoured nation" tariff concessions which, if granted, would expose this country to the full blast of foreign competition in its Commonwealth trade.

The United Kingdom is the only country publicly committed to opposing the admission of Japan, but other countries—even some of the 30 out of 34 who are said to have voted in favour of Japan's admission—are likely to invoke Article 35 of the Agreement by which any contracting party can refuse the benefit of the most-favoured nation clause to an acceded member on a reciprocal basis. The Australian Government have already announced that the provisions of the Agreement will not apply to the trade between the two countries, as Australia would be unable effectively to protect her industries from Japanese competition without raising duties on imported goods from other countries.

The American and German pressure on this and other countries to bring about convertibility and freer world trading conditions is unlikely to relax. But many factors enter into world trade, as is shown by prices quoted by Hungarian and Japanese locomotive builders to India. Multi-lateral free trade can kill as well as make healthier: it is unlikely that this country's Government will remove all safety barriers until it is satisfied that fair trading methods can be widely enforced.

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NEW INDUSTRY FOR NORTHERN IRELAND

Vigorous efforts are being made to attract manufacturing industry to Northern Ireland and some half-dozen projects now under consideration might initially employ up to 6,000 workers, and eventually, many more. The British Government and the Government of Northern Ireland have for some time been in consultation over a number of specific schemes and there is little doubt that the shortage of labour in England—particularly in the Midlands and the London area—is exerting as much influence on the parties concerned as the existence of a large and growing labour surplus in Northern Ireland. American as well as British companies are interested and taking part in discussions with the Ministry of Commerce, Belfast. Several of the projects are for the manufacture of motor-vehicle components to meet the rapidly expanding needs of car manufacturers but other industries are represented. The first decision since the discussions held in the spring was taken by G.W.B. Electric Furnaces Limited, Dudley, who are to establish a factory at Bangor to make control-gear equipment.

Two more schemes were announced last week: Birmingham Sound Recording are taking over a government-owned factory at Pennyburn and are to build a new factory at Drumahoe, both outside Londonderry; and the B.S.A. company are to take over a prominent factory at Carnmoney, Co. Antrim, where they will employ some 500 to 600 people mainly on government contracts, initially on the production of the new automatic Belgian rifle.

The growth of manufacturing industry in Northern Ireland since the war has been faster than in any of the British development areas (Weekly Survey, July 22). The geographical disadvantages from the point of view of English concerns appear to be more than outweighed by the relatively very advantageous financial and other terms offered by the Government. These include outright grants of 25 per cent. of the cost of capital expenditure, grants to offset the cost of transferring machinery, as well as certain tax and rents concessions.

Details of the facilities available and terms offered are given in a booklet entitled *Make It in Northern Ireland*, which certainly paints an attractive picture. Up to the beginning of this year capital and re-equipment grants had been paid to a total of £4½ million and the decision taken to make a further £5 million available. Under such conditions there is little doubt that to set up manufacturing facilities in Northern Ireland could be attractive, though transport costs and delays (particularly in the case of component manufacturers supplying factories in England) obviously require careful investigation.

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STEEL EXPANSION IN NORTH-EAST

The Iron and Steel industry's second development plan envisages a larger increase in pig iron and steel production on the North-East coast than in any other district. Between 1954 and 1958, pig-iron production is scheduled to increase by nearly one-third, and steel production by over one-quarter, to 3·65 million tons and 4·75 million tons respectively. During this period (including schemes started in 1953) projects that have been approved will involve an outlay of some £62 million.

An outline of the major projects in hand is given in the British Iron and Steel Federation's August issue of its *Statistical Bulletin*. Most of the increase in steel making capacity is based on a heavier use of pig iron, much of which is expected to come from a more intensive working of blast furnaces installed in recent years, though five new ones will be built. Three of these, two at Cleveland and one at West Hartlepool, will come into operation later this year, another—at Cargo Fleet—will be completed in 1956 and the last—at West Hartlepool—in 1957-58. The projected increase in pig iron output amounts to about 840,000 tons a year. Most of this will be based on imported ore, and by 1958 the district will be using 5·2 million tons a year, compared to 2·0 million tons of home ore. Additional ore handling plant and two new sinter plants will be built and great attention is being paid to the provision of adequate wharf and storage facilities. A large increase in coke-making capacity is envisaged—150 coke ovens at Dorman Long's Cleveland works, 20 at Consett and 26 at West Hartlepool.

The expansion of finished steel capacity includes a large 400,000 tons universal beam mill and a 175,000-ton rod, bar and narrow strip mill at Dorman Long's Lackenby works, as well as a medium section mill with an annual output of 175,000 tons at their Cleveland works. Extensions to medium and heavy plate capacity are planned at the South Durham Company's West Hartlepool and Cargo Fleet works. These two schemes will increase the company's medium plate output by 50 per cent. and that of heavy plate to 350,000 tons a year. These schemes are a logical result of the strong demand from the constructional engineering, shipbuilding and boiler plant industries which seem to have very good long-term prospects. Users of steel plate in particular, who have been starved of supplies almost continually since the war, will welcome these developments.

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MACHINE TOOLS IN DEMAND

The re-equipment and expansion plans of the vehicle and vehicle component industries are playing a major part in the marked increase in the rate of incoming orders for automatic lathes and for machines of the automatic transfer type. This was reported by Sir Stanley Dawson, Chairman of Wickman Limited, in his annual statement to shareholders last week. A consequence of the rising demand for machine tools has been an increase in the demand for the company's hard metals and cutting tools. Sir Stanley pointed out that the greater power and higher cutting speeds of modern machine tools calls for "constant research into, and development of new forms of cutting tools and more precise techniques in the production of the materials from which the tools are made." It is encouraging to learn that the percentage of export orders outstanding at the end of March was in excess of national average.

The improvement in the demand for machine tools reported by Wickmans is already reflected in the industry's statistics of deliveries and orders in hand. During the first four months of this year their average monthly output was £5·8 million, nearly 9 per cent. higher than in the corresponding period last year and orders on hand at the end of April stood at £88·2 million, compared with £70·6 million a year previously. If one assumes that orders are evenly spread over all the companies in the industry and all the main types of machines, the average delay for deliveries would be approximately fifteen months at the current rate of output. The demand, however, is tending towards more-automatic and special machinery, for which delivery dates in some cases run into two or three years.

To get into a position of having to quote lengthy deliveries is an unfortunate handicap in overseas markets where competition is becoming most acute; deliveries for export were only about 2½ per cent. higher up to April this year than last, and a great deal more will be expected from the industry to help the country out of its balance of payments crisis. The shortage of labour is a serious factor in limiting the extent to which production can be increased, and it should not, of course, be forgotten that re-equipment of the engineering industry is a vital matter. Nonetheless a large and well-balanced export trade in machine tools is necessary, as much for the industry's long term prospects as for the country's balance of payments.

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EXPORTING NUCLEAR POWER STATIONS

A major obstacle to the development of a British export trade in nuclear reactors and atomic power stations was removed when spokesmen of the United Kingdom Atomic Energy Authority stated that the appropriate uranium fuel would also be made available. Sir Christopher Hinton, head of the industrial group of the Authority, said that natural uranium fuel for power stations would be supplied to companies who obtained orders, and enriched uranium for research reactors through special agreements. The supply of enriched uranium fuel for atomic power stations which required it was still being considered. Exports of this type of nuclear reactor are unlikely to start before the end of 1960, but if British manufacturers are to hold their own the fuels will have to be available.

Sir Christopher also spoke of the very large British programme now in hand but said that important operating problems still awaited solution. Britain would naturally be unwilling to supply untried reactors and he mentioned a period of three to five years at the end of which complete atomic power stations could be sold to countries having scientific and engineering experience. While Sir Christopher may be right in his timing, his speech does not take into account the sense of urgency present in the announcements about enquiries and orders for atomic plant from this country and the United States. The sale of a plant to the Fiat Motor Company by Westinghouse Electric was virtually confirmed last week and the company are now awaiting U.S. Government sanction which is not expected to be withheld. Westinghouse are said to be interested in the production of small reactors on an "assembly line" basis and they were reported to be selling hard at Geneva.

The four major groups of British companies capable of constructing complete atomic power plants reported serious enquiries by eight different countries, including Western Germany, Italy and Israel. Several of the enquiries are for small-capacity plants from 5 to 30 MW and some for large stations of the Calder Hall type, with capacities up to 200 MW. It seems that British companies will have to take orders quite soon if they are not to be left behind in the race. The announcement about supplies of uranium fuel was therefore of considerable importance.

STANDARDISATION

ITS PROGRESS AND ECONOMIC ADVANTAGES

Since the war there has been an increasing interest in the advantages of standardisation and simplification, both as safeguards for the consumer and as a means of raising productivity and reducing costs. Wars, with their resulting demand for the manufacture of vast quantities of similar products to the exclusion of most inessentials, have always given an impetus to the techniques of mass production and it is perhaps not surprising that, immediately after the last one, a Government pledged to raising the standard of living and so greater equality, but faced with the serious economic difficulties of the post-war world, should have encouraged the extension of the process.

AN AID TO PRODUCTIVITY

Support was given to the official view by many of the reports of the Anglo-American Productivity Council, which pointed to standardisation and simplification of design as one of the outstanding causes of American productivity. Two of the reports, one published in 1949 and one in 1950, dealt specifically with this subject. A committee, under the chairmanship of Sir Ernest Lemon, to investigate the standardisation of engineering products, was set up by the Minister of Supply in 1949 and, apart from general recommendations to industry, it made a number of detailed proposals.

The proposals that were made included setting up organisations to represent users of special products, the charging with responsibility for standards work of a senior official in each firm, the use by Government Departments and nationalised industries of B.S.I. standards wherever possible, the compilation of standards books by individual firms and by appropriate sections of industry, and the strengthening of the staff of B.S.I. so that it could take a more active part in initiating action for the preparation and co-ordination of standards. Arising out of the last recommendation, the Cunliffe Committee was set up in 1950 to examine the B.S.I. and, as a result of its report, the Government grant to the Institution was increased, so that its income is now over £600,000, compared with under £400,000 in 1949-50. It was also enabled to move to its present new and larger premises in Park-street, London, W.1.

It is perhaps surprising that, even in quite a large number of engineering firms, the advantages of standardisation are still not appreciated. To-day, the B.S.I. is doing a good deal of educational work to overcome this; members of the staff give lectures to trade and professional associations and to students at technical colleges and universities, and the Press department has, during the last two or three years, been strengthened. This publicity should be assisted by a number of pamphlets* recently published by the B.S.I. itself, by the British Productivity Council, and by P.E.P.

The P.E.P. pamphlets provide a useful historical and descriptive background to the work of the B.S.I. and also some information on the corresponding organisations in a number of other countries.

DIVISIONS OF STANDARDISATION

Although standards are generally described as of two types, "functional" and "dimensional," they are probably better grouped into four, according to whether the specification is by performance, chemical and physical properties, or dimensions, or is for purposes of "communication" and recognition. Most specifications cover more than one of these aspects. Dimensional standards, which started with small engineering components such as screws, nuts and bolts and with steel sections, now cover a large number of machinery details and finished goods, including quite large assembled units such as cranes, conveyors, fans and electric lifts.

Standard classifications are frequently of help in plant maintenance or for preventing accidents: examples of this type are colours for pipe work or wiring, colours and names to be used for the identification of medical gases, railway signalling symbols, road traffic control symbols, and graduation markings for instruments. The choice of these is frequently the result of extensive research work by applied psychologists working in units sponsored by the D.S.I.R. and the Medical Research Council. Standards of drawing office procedure, of symbols for use on diagrams of chemical plant or telecommunication equipment, glossaries of the terms used in particular industries, names of chemicals used in industry, and the nomenclature of timber, are examples of specifications which help to avoid error and speed design and purchasing procedures.

COMPONENT CLASSIFICATION

In this field also are systems of classification by means of which parts can be quickly identified. The most advanced system of industrial classification is that developed by E. G. Brisch and Partners, of Westminster, and already adopted by a number of large companies. Under this system materials and components, or partly finished components, are classified by decimal numbers according to their basic design and material features. When this is done in a large organisation it is always found that there are a large number of components which almost duplicate each other and, if they cannot be reduced to one exactly similar design, they can probably be brought as near it as will allow of a very considerable reduction in stocks held in the form of raw or partly machined material. This involves a process of standardising materials and component designs within the individual firm and the resultant reduction in stocks that have to be held is one of the main economic advantages of standardisation and one which applies to the industries producing large capital goods who cannot take advantage of the economies to be derived from a reduction in the numbers of types of finished products which they manufacture.

To achieve this there must be someone in the firm responsible for the work and for compiling the necessary standard books covering the designs and materials which are selected and it is, therefore, unfortunate that the recommendation made by the Lemon Committee for such an appointment has been carried out in so few firms in this country. In the United States, a Standards Engineers Society has been flourishing for fifty years and has a large number of members. The recent conference of engineers concerned with standards, organised jointly by the Institution of Production Engineers and the British Standards Institution, was a welcome step in the right direction.

STANDARDS FOR THE USER

Another recommendation of the Lemon Committee on which there has been little progress is that for the formation of users' organisations. The chemical and electrical industries have for many years played a big part in the work of the B.S.I., but more in the specification of the products they manufacture than of those they use. There has been in existence for some time an Oil Companies Materials Committee and, in 1949, the Engineering Equipment Users' Association was formed by a number of large users of engineering equipment, particularly those engaged in the chemical industry.

The main object of this body is to ensure a co-ordinated policy for users on the specialised technical committees of the B.S.I., which otherwise tend to be dominated by the manufacturers of the equipment or material concerned. Most of its services have now been made available to associate members who may not wish to accept the responsibilities of full membership but who are otherwise acceptable; some of the nationalised industries have become associate members. It was because of their importance as purchasers that the Lemon Committee was particularly anxious that the nationalised industries should collaborate with and strengthen the B.S.I. in their work.

The Engineering Equipment Users Association, in addition to representing its members on B.S.I. technical committees, draws up draft standards for the use of its members, although it always tries to get these adopted as B.S.I. specifications wherever possible. Subjects covered in this way include steam traps, steel stairways, handrails and ladders, chemically-resistant linings for pipes and vessels, packaging for protection in transit and storage, and the protection of steel. Some criticism has been expressed of the attempt of the Association to get dimensional standards accepted for such large items of equipment as centrifugal pumps on the ground that to limit the external dimensions might inhibit the design of the functioning parts. On the other hand, similar standardisation seems to have been successfully achieved in the case of a very large range of electric motors without loss of functional range.

The formation of a standards department within the Society of Motor Manufacturers and Traders, although it will largely deal with components manufactured by the Society's own members, will presumably also provide co-ordinated opinion of the requirements of the motor industry as purchasers.

INTERNATIONAL CO-OPERATION

The needs of defence and the growth of the export business, in engineering products particularly, has led to an intensification of work on the establishment of international standards. A number of major industries have already accepted the Unified Screw Thread, although the nationalised industries have so far been reluctant to do so. The changeover has been easier than was expected, possibly because the pitches of all the threads in the coarse series (except ½ inch) are the same as Whitworth and 90 per cent. of the sizes are interchangeable (at a pinch) with Whitworth sizes. The Engineering Equipment Users' Association has issued a handbook to assist its members in the introduction of the new thread.

The International Organisation for Standardisation which was founded in 1946, has made 80 recommendations for adoption by national bodies, 60 per cent. of them in the field of engineering, and has produced a series of preferred pitches for screw threads above certain sizes which is very near the unified thread series and which is likely to be universally adopted. Through the International Electrotechnical Commission, standards for performance tests of motors have been established and new dimensional standards are being developed for fractional horse-power motors and for three-phase motors of up to 20 h.p. rating. The European Productivity Agency is working on an international system of modular units for building construction.

The importance of this work in the international sphere is demonstrated by the fact that the triennial meeting of the General Assembly of the I.S.O. held last June in Stockholm was addressed by a representative of the Secretary General of the United Nations, who spoke of the help which I.S.O. could give to other bodies such as the Economic Commission for Asia and the Far East. I,S.O. is already giving assistance to under-developed countries in a number of ways and the extension of this assistance was one of the subjects which were discussed at the Stockholm meeting.

* *How British Standards Serve Industry*. British Standards Institution. *Standardisation: An Aid to Productivity*. British Productivity Council. *Standards in Industry*. P.E.P. *The British Standards Institution*. P.E.P.

BRUSSELS INTERNATIONAL EXHIBITION

Post-War Progress

In November last, Her Majesty's Government accepted an invitation to take part in the international exhibition at Brussels in 1958, which is being organised under the auspices of the Belgian Government. It has now been announced that Sir John Balfour, G.C.M.G., previously British Ambassador to the Argentine Republic and Spain, has been appointed Commissioner General for the United Kingdom, in respect of the exhibition. Sir John will have overall responsibility to the Secretary of State for Foreign Affairs for the organisation of the British contribution, and an advisory committee is being set up to assist him in the task.

The aim of the exhibition, which will be known as "The Universal and International Exhibition of Brussels, 1958," is to present on a world-wide scale the spectacle of man's technical, cultural and social progress during the post-war period, and to provide an opportunity for each country to display its own most outstanding achievements during those years, in science, art and industry. The Belgian Government anticipate that the exhibition will serve, in this way, as a major vehicle for strengthening international understanding and goodwill.

The exhibition will be opened in mid-April, 1958, and is expected to continue until the middle of the following October. It will occupy an area of about 450 acres of parkland, some four and a half miles from the centre of Brussels. Part of the site is in the grounds of the royal palace of Laeken and has been placed at the disposal of the exhibition authorities by the King of Belgium, under whose direct patronage the exhibition is being held.

A special feature of the exhibition will be the three international Halls of World Co-operation, Science, and Art. The Hall of World Co-operation will be designed to illustrate the development of the world's social and economic wealth, laying particular stress on the assistance given to under-developed territories by the more experienced nations. The International Hall of Science is intended to demonstrate, on an international scale, recent scientific progress viewed as part of the heritage of mankind in general. The International Hall of the Arts will enable each country to present some typical examples of its own particular achievements, as illustrations of its contributions to world culture.

Further particulars respecting the progress of arrangements for the exhibition may be obtained from Campbell-Johnson Limited, 35 Old Bond-street, London, W.1.

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PUBLIC HEALTH ENGINEERING COURSES

Five Years Experience in London

The fifth post-graduate course in public health engineering, provided jointly by the Imperial College of Science and Technology and the London School of Hygiene and Tropical Medicine, was held from October, 1954, to June, 1955. Applications for admission were greatly in excess of those received in previous years and it was necessary to reject a number of prospective entrants owing to the shortage of accommodation.

Of the 17 students accepted, only five were natives of the United Kingdom. The remainder came from places as far distant as Canada, Australia, Malaya, Ceylon, Pakistan, South Africa, Gold Coast, Nigeria, Egypt, Portugal and Finland. Post-graduate courses on this subject have been organised by the two colleges, which are attached to the University of London, for the past five years, and an appreciation of the international character of the students attending during that period may be obtained by noting that, of the total 54 engineers who have been trained, 17 came from the United Kingdom, 14 from the colonies, 13 from other Commonwealth territories, and ten from foreign countries. Financial assistance was provided for all but four of these students, and awards held by the others included 25 Rockefeller Bursaries, seven World Health Organization Fellowships, two Athlone Fellowships, two Beit Railway Trustee Fellowships, two British Council Scholarships and one Colombo Plan Fellowship.

Twelve engineers, including one holder of a Rockefeller Bursary, attended courses with the financial assistance of colonial or other Governments. These facts show how very few students are able to take post-graduate courses without monetary help, and this applies with special force to men who are already established in engineering practice and who have family commitments. In the fifth course, the average age of the students was 28 and some had had up to 14 years of practical engineering experience each. The decision of the Rockefeller Foundation to place a further sum of money at the disposal of the Institution of Civil Engineers for the award of bursaries in public health engineering during the next five years is accordingly a particularly welcome one.

Throughout the past five years, the syllabus of the courses has remained basically unaltered. As previously, lectures on special topics, such as the conservation of organic wastes, limnology, and housing in the tropics, have been given by visiting authorities. As a complementary arrangement to that by which students of public health engineering spend part of their time at the London School of Hygiene, greater emphasis has been laid during the last two years on the training of doctors in the problems of environmental control by engineering and similar means, as part of their work for the Diploma in Public Health.

* * *

FRENCH RAILWAY DEVELOPMENT

La Société Nationale des Chemins de Fer Francais, the British representatives of which are French Railways, Limited, 179 Piccadilly, London, W.1, have published a brochure describing the developments which have taken place on their system since the end of the war. It will be read with interest both by amateur railway enthusiasts and professionals, for it provides a striking account of how wartime ravages have been repaired and the high degree to which both equipment and methods of operation have been modernised.

It having been postulated that a railway's basic concern is to combine maximum hauling capacity with minimum hauling power, track construction, especially the use of a rubber sole between the rail and the sleeper, and the other steps taken to ensure smooth running, are described. Considerable space is next devoted to the rolling stock, attention being particularly drawn to the design and performance of the electric locomotives now in use, as well as to the Diesel rail cars, passenger carriages and goods wagons. In this connection, the importance of well-organised maintenance methods is stressed.

Not the least interesting portion of the booklet is the section devoted to the Traffic Department. The methods that have been successfully adopted to reduce the cost of running passenger trains without decreasing the quality of the service, safety measures, train control and such details as cleaning and seat reservation, are described. Due regard in this connection is paid to the working of the freight department, which though less spectacular accounts for 70 per cent. of the railway's receipts. What is being done in the way of research is also described, and there is a good deal of interesting information about the commercial department and the personnel, the number of which, it is interesting to note, has been reduced from 520,000 in 1938 to 380,000 in 1955, in spite of an increase of 20 per cent. in passenger and of 65 per cent. in freight traffic.

Finally, a word must be said about the excellence of the illustrations, which include a number in colour, as these add to the interest of the "story" in a most convincing way.

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CLAYTON FELLOWSHIPS AND GRANTS IN 1955

Awards to Young Engineers

The Council of the Institution of Mechanical Engineers have made the undermentioned awards for 1955, for special industrial experience, post-graduate studies or research in mechanical engineering, under the terms of the James Clayton bequest. The total value of the awards is approximately £4,450, compared with awards valued £6,400 in mid-1954.

FELLOWSHIPS

Overseas Awards: Mr. R. G. BARDEN, B.Sc. (Eng.), A.M.I.Mech.E., University of Adelaide, Australia, for post-graduate studies at Birmingham and London Universities; and for a course at the Reactor School at Harwell. Mr. J. R. HATFIELD, B.Sc. (Eng.), G.I.Mech.E., Uganda Electricity Board, Kampala, Uganda, for a course at the College of Aeronautics, Cranfield.

Awards in Britain: Mr. R. E. CATTERWELL, G.I.Mech.E., Woking, for a course at the College of Aeronautics. Mr. T. P. CONWAY, G.I.Mech.E., London, N.14, for research at Sheffield University. Mr. B. K. FOSTER, B.Sc., G.I.Mech.E., Nottingham, for research at Nottingham University on cumulative damage in fatigue. Mr. D. K. HOLLIDAY, B.Sc. (Tech.), G.I.Mech.E., Wallasey, Cheshire, for the continuation of research at Sheffield University on flame radiation. Mr. D. L. MUIR, B.E., S.I.Mech.E., Barkingside, Essex, for a course in production engineering at Birmingham University and for visits to firms. Mr. P. J. B. SOLOMON, B.Sc., A.M.I.Mech.E., Bournemouth, for research at Imperial College on oil whirl. Mr. D. J. WHITE, G.I.Mech.E., Bristol, for research at Bristol University on the effect on a material of direct fatigue stress with superimposed triaxial compression. Mr. D. S. WHITEHEAD, B.A., S.I.Mech.E., Cambridge, for the continuation of research at Cambridge University on gas-turbine blades.

GRANTS

Overseas Awards: Mr. C. J. RALLIS, M.Sc., G.I.Mech.E., Witwatersrand University, Johannesburg, South Africa, for a special course of practical training with the English Electric Company, Limited, and a course at the School of Gas Turbine Technology, Farnborough. Mr. N. R. SHERIDAN, B.E., A.M.I.Mech.E., Queensland University, Brisbane, Australia, for a course in thermodynamics at Birmingham University and for visits to firms and universities in the United Kingdom and on the Continent.

Award in Britain: Mr. P. L. B. OXLEY, B.Sc., S.I.Mech.E., Barwick-in-Elmet, near Leeds, for the continuation of research at Leeds University on metal-cutting processes.

* * *

TURBINES FOR CIVIL AIRCRAFT

The Plesman Memorial Lecture

The first "Albert Plesman Memorial Lecture" will be held in the Technological University at Delft on September 12.

Dr. Plesman was the founder of K.L.M. Royal Dutch Airlines and until his death in December, 1953, was President of the Company.

Sponsored by the International Air Transport Association, these lectures will become annual events. This year, the introductory speech will be made by Sir William Hildred, director-general of I.A.T.A., and Mr. J. D. Pearson, of Rolls-Royce, will speak on "The Development and Future of the Turbine Engine for Civil Aircraft."

Letters to the Editor

THE NEWER METALS

Their Properties and Their Uses

SIR, I have just had my attention drawn to the article on " The Newer Metals " which appeared on page 172 of your journal of August 4.

There, one is told that " it is normal to consider these metals (i.e., tantalum, titanium, zirconium, chromium, cobalt, molybdenum, tungsten and vanadium) either as ferro-alloys or carbides and to neglect their possible use in pure form or in alloys with other non-ferrous metals." It is quite untrue to state that the use of these metals in their pure form has been neglected. For example, in the year ending June 30, 1955, our company sold 22,115 kgm. of pure tungsten as sheet, rod and wire, 3,876 kgm. of molybdenum and about 500 kgm. of tantalum. These may appear to be small quantities in relation to the hundreds of tons of ferro-alloys which we sell, but they represent a very important part of our business in supplying materials to industries which employ a large number of people in this country and abroad.

The author of your article appears to be under the impression that these materials, in general, are only produced in the United States, as there are several references to the U.S. The production of molybdenum and tungsten in the pure form as sheet, rod and wire has been carried on in England for a long time, and it is wrong to refer to these metals as " newer " metals. This statement also applies to tantalum, cobalt and chromium. Tantalum has been produced as a pure metal for over 50 years. Titanium, zirconium and vanadium are the only metals which could truly be termed the " newer " metals.

It is surprising to see the statement that there are no quotations available for columbium, tantalum, titanium, or zirconium. In the case of both tantalum and zirconium, our company will be pleased to quote. As far as columbium is concerned, we have been engaged on the extraction of this metal for some time and believe we were the first in this country to produce ductile metal. We hope, eventually, to put this metal on a production scale.

One also notes the statement that " titanium metal (99·3 per cent.) is £1 10*s.* per lb. and zirconium £2 10*s.* per lb. for the powder, both in the United States." One wonders how useful 99·3 per cent. titanium powder is going to be in the production of ductile titanium metal. As far as the zirconium powder is concerned, this price probably applies to the materials sold for flash-light powder, which is produced as a low-grade metal containing a great deal of oxygen to reduce the hazard of handling the powder. The same misleading statements apply to other quotations, e.g., tungsten powder is quoted for the 98/99 per cent. grade whereas such material is utterly useless in the production of pure tungsten.

The author's rhetorical question " What have these rare and expensive metals to offer? " and his statement " At present it (columbium) is far too rare and expensive to be of interest in pure form," make one want to cry out in protest. These metals are not rare and apparently they are not too expensive to find a use. In the case of columbium it is assumed the statement " far too rare "applies to the ore, and this statement is quite out of date as there are ample supplies of ore in Africa.

The reasoning behind the following statement about tantalum is rather curious—" being of less interest as a ferro-alloy than ferro-columbium, there is a possibility that in due course it will be used at least to a moderate extent for chemical plant."

In the case of zirconium, it is surprising to learn from the article that " Too little zirconium metal is available to offer useful comment on its commercial potentialities." Production of zirconium in the United States for the last three years at least has been of the order of 100 tons per annum. Production in the United Kingdom has only been on a scale of a few tons per annum but sufficient to supply material for potential users to indicate their interest. The corrosion-resistant properties of zirconium are different from those of titanium, and zirconium is much more resistant to most chemicals. The most interesting property of zirconium is its low neutron absorption and it is prominent in the minds of designers of nuclear reactors.

It seems odd to see chromium described as a " newer " metal and then to find there is not one reference to the attempts which have been made to produce pure ductile chromium. Cobalt metal has also been in production for many years, and again it is difficult to understand how it can be described as a " newer " metal.

In the case of molybdenum, this metal possesses extremely good high-temperature properties. There is plenty of it available and it should become much cheaper, although the cost compared to its usefulness is not unduly high. Interest in the United States today is growing, particularly in view of the promising results obtained for molybdenum coated with oxidation-resistant alloys. The use of such a combination for jet-engine blades shows great promise.

It would be possible to go on for a long time pointing out errors and points of controversy in this article, but I will close by referring to the last sentence which states that it may be found that a tungsten layer on a non-ferrous metal gives properties which are a marked improvement over tungsten in a non-ferrous alloy. That anyone should assume that the properties of pure tungsten are similar to the properties of an alloy containing tungsten seems to me to be remarkable.

Yours faithfully,
For MUREX LIMITED.
G. L. MILLER.
Research Manager.

Rainham,
Essex.
August 15, 1955.

[*Editor's Note:* Dr. Miller's letter was received just too late to publish in our last week's issue and, meanwhile, there has been time to send a copy to our contributor, Mr. P. W. Wigram, whose reply is published below.]

SIR, Dr. Miller will no doubt appreciate that the article as originally prepared proved longer than could be accommodated in the space available and as a result it was heavily cut. Unfortunately one of the sections which was eliminated was that describing the production of these metals in the United Kingdom and containing a number of references to the activities of his company. I have the greatest admiration for this company and its research manager who have made contributions to the study of these metals probably unparalleled by any other private concern in Europe or America. It is therefore untrue to suggest that I was under the impression that these metals were produced only in the United States of America.

Objection is taken to the title. Butterworths (the publishers) in their series of books on these metals, to which Dr. Miller has contributed a volume on zirconium, described them as " The Rarer Metals." This, I think, is equally open to objection since, to a chemist at least, the rare or rare earth metals are a definite group in no way related to those under consideration. I think the title *was* a reasonable one, since they are relatively new in comparison with iron and the common non-ferrous metals.

Perhaps Dr. Miller's pre-occupation with the production of pure metals has obscured the fact that the great majority of those who handle these newer metals use them as alloys or carbides. The figures he quotes for this company's sales are most interesting, but the quantities are extremely small in comparison with the amounts used in ferro-alloys and carbides. It is unfortunate he has not given the latter figures for comparison. The position in the United States is similar as can be determined from the statistics published annually by the U.S. Bureau of Mines. There are, in fact, for the metals referred to in Dr. Miller's third paragraph, no regular *market* quotations published in such journals as *The Metal Bulletin*, *The Metal Age* or the quarterly journal of the Colonial Geological Survey entitled *Colonial Geology and Mineral Resources*.

Dr. Miller's other points are less easy to deal with. I did not say that either columbite or tantalite was rare, but that columbium metal is too rare and expensive to be extensively used, which is perfectly true. Tantalum is of interest for chemical plant, as the Fansteel Corporation in the U.S.A. has proved. Unfortunately there is no equivalent of Fansteel in this country. It was noted in the article that the principal current use for zirconium was to applications related to atomic energy, but more emphasis was given to its potential use as a material of construction for chemical and process plant, though I have not in fact heard of its commercial employment for this purpose here. We do not seem to be in conflict regarding the potential use of molybdenum.

As regards Dr. Miller's final paragraph, what is the commercial justification for the production of clad metals of any description, such as stainless-clad mild steel?

Yours faithfully,
P. W. WIGRAM.

Westminster, S.W.1.
August 18, 1955.

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DESIGNING MODERN ROADS

Courses at R.R.L.

A number of courses of lectures dealing, as in previous years, with the fundamental properties of road materials, and including the results of recent research and their application to modern practice, have been arranged by the Road Research Laboratory, for delivery during the coming months at the Harmondsworth headquarters.

A course on soil mechanics, to be held from Tuesday, November 22, to Wednesday, November 30, will give full consideration to the latest developments regarding moisture movement in soils, sub-soil drainage, soil stabilisation, the compaction of soils, earthworks, methods of pavement design, and the construction of road foundations. It will be assumed that persons taking this course have at least an elementary working knowledge of soil-survey procedure and of soil-classification tests, including the determination of liquid and plastic limits and particle-size analysis.

There will be a course on tar and bituminous materials from Tuesday, December 6, to Wednesday, December 21, and two courses on concrete, one from Tuesday, November 8, to Thursday, November 17, and the other from Tuesday, January 10, to Thursday, January 19, 1956.

A course on traffic and road safety will be held from Tuesday, March 13, to Wednesday, March 21, 1956, at the Laboratory's Traffic and Safety Division, Langley Hall, near Slough. These lectures will include the most recent theories and research results on matters relating to traffic engineering and road safety. The course is designed to meet the requirements of senior officials and of men primarily concerned with traffic-engineering and road-safety problems. Opportunities for discussion will be provided.

Each course will be entirely self-contained. An inclusive fee of seven guineas will be charged for the course on traffic and road safety and of ten guineas for each of the other courses. These amounts will cover tuition, registration, and any materials which may be required. Accommodation is not provided by the Laboratory but a list of local hotels will be supplied on request. Forms and further details are obtainable from the Director, Road Research Laboratory, Harmondsworth, Middlesex.

PERSONAL

MR. G. A. WILSON, M.Eng., M.I.C.E., M.I.Mech.E. chief engineer of the Port of London Authority, London, E.C.3, has been appointed to succeed the late Sir Athol Anderson, K.C.B., as one of the British nominees on the International Consultative Works Commission of the Suez Canal.

GROUP CAPTAIN B. H. BECKER, A.F.R.Ae.S., R.A.F. (ret.), has been appointed technical manager, turbo-propellers, to D. Napier & Son Ltd., The Vale, Acton, London, W.3. He will be responsible to MR. A. J. PENN, chief engineer of the company's gas-turbine division.

CAPTAIN G. O. NAISH, M.I.Mech.E., R.N., has been promoted to rear admiral with effect from August 29; he will take up engineering duties on the staff of the C.-in.C. Portsmouth in succession to REAR ADMIRAL N. E. DALTON, O.B.E., on September 2. CAPTAIN J. W. FURSE, O.B.E., R.N., has been promoted to rear admiral with effect from September 19, when he will become director of aircraft maintenance and repair in succession to REAR ADMIRAL J. D. N. HAM, C.B.

MR. G. G. JACKSON, B.Sc., formerly with the Atomic Energy Research Establishment, Harwell, has been appointed chemical engineer to Sharples Centrifuges Ltd., and will be based at the company's Tower House Laboratories at Stroud.

MR. WILLIAM JEFFERS, a present dock manager, Swansea, has been made chief docks manager, South Wales Docks, British Transport Commission, with headquarters at Cardiff. He succeeds MR. A. E. H. BROWN, T.D., M.Inst.T., who, as stated on page 555 of our issue of May 6, is to become general manager, Scottish Region, British Railways, on the retirement of Mr. T. F. CAMERON next month.

MR. C. M. SPIELMAN, O.B.E., M.C., M.I.C.E., M.I.Struct.E., has been elected chairman of Whessoe Ltd., Darlington. He joined the firm in 1923 as works manager and became managing director in 1935. He relinquished this position on September 30, 1954, but retained his seat on the board.

MR. ROBERT ATKINSON, D.S.C., R.D., B.Sc., A.M.I.Mech.E., has relinquished the appointment of director and general manager Hamworthy (B.C.E.) Ltd., to become director and general manager, Hamworthy Engineering Ltd. (Pump and Compressor Division), Fleets Corner, Poole, Dorset. MR. L. C. BAKER, D.S.C., M.I.Mech.E., has resigned the appointment of chief superintendent engineer, Alfred Holt & Co. Ltd., to become general manager of Hamworthy (B.C.E.) Ltd.

MR. G. D. TOOGOOD, A.M.I.Mech.E., general manager of Heat Exchangers Ltd., has been elected a director of the company, which is a subsidiary company of the Superheater Co. Ltd., 53 Haymarket, London, S.W.1.

MR. WILLIAM PAYNTER has relinquished the position of production manager, special products division, E. K. Cole Ltd., Southend-on-Sea, Essex, to take up that of works manager, Mervyn Instruments, Copse-road, St. John's, Woking, Surrey.

MR. E. C. WHITELEY has been appointed manager, Middle-East division, Metropolitan-Vickers Electrical Export Co. Ltd., Trafford Park, Manchester, 17.

MR. D. J. BOLTON, M.Sc. (Eng.), M.I.E.E., retires from the Central Electricity Authority on August 31 after 5 years in their commercial department. He is taking up work as a consultant in association with Messrs. Kennedy and Donkin.

MR. WALTER MEECH has been appointed commodore chief engineer officer of the fleet of the British India Steam Navigation Co. Ltd., 122 Leadenhall-street, London, E.C.3, in succession to MR. W. JOHNSON, who is retiring.

MR. W. PLUMB has been appointed deputy commercial manager for the Liverpool and Netherton Works of the English Electric Co. Ltd. For the last six years Mr. Plumb had been manager of the Leeds branch office of the company and he is succeeded there by MR. A. J. EVANS.

MR. WILLIAM HOLYOAK has been appointed production manager at the Fort Dunlop factory of the Dunlop Rubber Co. Ltd., in succession to the late MR. T. S. GARDNER.

MR. E. WATT has been appointed Chester branch manager of British Insulated Callender's Cables Ltd., as from September 1.

Certain changes have been made in the senior staff appointments in the engineering division of F. Perkins Ltd., Peterborough. MR. J. R. CONDIE, executive engineer, is now manager of the design department. This is a new appointment and supersedes that of chief engineer, previously held by MR. A. W. GOSLING, who is relinquishing the appointment. MR. J. G. DAWSON, B.Sc., A.M.I.Mech.E., A.F.R.Ae.S., M.Inst.F., has been appointed manager of the experimental department, with effect from September 1; he was previously chief engineer of the Thornton research centre. MR. M. VULLIAMY, M.A. (Cantab.), A.M.I.Mech.E., will continue as chief experimental engineer. MR. W. SPOOR, A.M.I.Mech.E., A.M.I.Loco.E., has now been appointed assistant to the director of the engineering division, MR. M. I. PRICHARD.

MR. GILBERT DODD, who joined the sales division of Monsanto Chemicals Ltd. in 1939 and has been general manager of Monsanto Plastics Ltd. since its formation on December 31, 1953, has now been elected a director of Monsanto Plastics Ltd.

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COMMERCIAL

LANCASHIRE DYNAMO HOLDINGS LIMITED have announced the formation of a new company in Australia, namely, LANCASHIRE DYNAMO COATES PTY. LTD. This development follows upon nearly 30 years' representation of Lancashire Dynamo Companies in Australia by COATES & CO. PTY. LTD. The new company will handle all inquiries in the State of Victoria, South Australia and Tasmania from their head office in Melbourne and a branch office will cover New South Wales. Representation in Queensland will be made by Coates and Co. Pty. Ltd., and in Western Australia, HARRIS SCARFE AND SANDOVERS LTD. will continue to represent companies in Great Britain and will act as agents for Lancashire Dynamo Coates Pty. Ltd., in connection with Australian-made equipment.

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OBITUARY

We regret to record the deaths of:—

SIR CHARLES JOHN BARTLETT, at his home near Harpenden, Hertfordshire, on August 10, at the age of 65. Sir Charles was managing director of Vauxhall Motors Ltd., Luton, Bedfordshire, from 1930 until 1953, and chairman from June, 1953 until he retired last December. He joined General Motors Ltd., as a book-keeper in 1921, and became managing director of that company in 1926. He was knighted in 1944.

MR. HERBERT BLIN STOYLE on July 27 at Nairobi, aged 64. A former Chief Mechanical Engineer, East African Railways and Harbours, he had served abroad since he completed a premium apprenticeship under Dugald Drummond on the London and South Western Railway.

MR. EUSTACE WILLIAM PORTER, M.B.E., M.I.C.E., of "Drumfield," Inverness, on August 4, in his 84th year. Mr. Porter was for a long period engineer and manager, Caledonian Canal, Inverness, Fort William. He began his career as an indentured apprentice with the locomotive superintendent, North London Railway Co., and was afterwards a pupil under the late Sir James Inglis, engineer-in-chief to the Great Western Railway Co. Mr. Porter was subsequently engaged on civil engineering works in Calcutta, London and Southampton, and served in the department of the Admiralty civil engineer-in-chief for seven years. From 1912 until his retirement some 25 years later, he was resident engineer and manager, Caledonian Canal.

MR. HARDY KELVIN PARSONS, at his home at Oadby, Leicestershire, on August 11, at the age of 53. He was managing director of Gent & Co. Ltd., Faraday Works, Leicester. Mr. Parsons joined the firm in 1923 after education at Uppingham and Cambridge University; he was elected a director in 1931 and managing director in 1946. He was a freeman of the City of London, a Fellow of the British Horological Institute, and an associate member of the Institution of Railway Signal Engineers.

ENGINEER REAR ADMIRAL EDWARD OWEN HEFFORD, O.B.E., at Paignton, Devon, on August 7, at the age of 84. He entered the Royal Navy in 1886, and attained the rank of engineer captain and received the O.B.E. in 1919. He retired with the rank of engineer rear admiral in 1925 after serving for some two years as Engineer-Overseer for the London District. From 1921 until 1923 he presided over the Allied Dockyard Commission, Constantinople.

MR. ARTHUR KENRICK RHODEN, on July 25. Mr. Rhoden acted as overseas representative for Sanderson Brothers and Newbould Ltd., Newhall-road, Sheffield, for upwards of 40 years. He retired in 1943.

CONTRACTS

Television Equipment. The Australian national television service is expected to be inaugurated towards the end of next year upon the completion of the first two Government-controlled stations and studio centres, at Sydney and Melbourne. Most of the equipment for the transmitting stations in these two cities is to be provided by MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex, under the terms of a recently-signed contract worth more than £250,000 obtained through the firm's Australian associates, AMALGAMATED WIRELESS (AUSTRALASIA) LTD. The installation at Sydney and Melbourne will consist of an 18-kW vision and a 4-kW sound transmitter, together with a 5-kW vision and a 1-kW sound transmitter as standby equipment. In addition, the Marconi Company will be supplying the combining units for both main and standby transmitters, a twin transmission line, an eight-stack aerial for each station, and various ancillary equipment.

It is of interest that the main vision transmitters to be installed are of the same type as those which the Marconi Company are supplying to the British Broadcasting Corporation for their new Crystal Palace station. Like all the firm's latest vision transmitters, those to be installed at Sydney and Melbourne are designed to handle the National Television Standards Committee (N.T.S.C.) type colour transmissions, as well as the normal black and white. The Marconi Company have also been awarded an order for two complete camera channels, with ancillary equipment, which, it is understood, are to be used for training purposes at Sydney and Melbourne. The Australian Government stations will operate in Band I to a 625-line standard, and the sound transmissions will be frequency-modulated.

Oil-Filled Cable. A first contract for 132-kV three-core oil-filled cable was placed with W. T. HENLEY'S TELEGRAPH WORKS CO. LTD., earlier this year by the Central Electricity Authority on behalf of the North-West, Merseyside and North Wales Division. The Central Electricity Authority have now placed with the firm a contract involving further lengths of 132-kV three-core oil-filled cable. This has been placed on behalf of the Midlands Division for connections at Nechells "A" and "B" power stations. It covers the supply and installation of 800 yards of 0·2 sq. in. 132-kV three-core oil-filled cable and approximately 3,500 yards of 11-kV single-core and low-voltage multicore auxiliary cables. As was the case for the previous contract, the 132-kV cables will be designed to operate at a maximum stress of 100 kV/cm.

Electricity Generation and Distribution Plant. The contracts placed by the Central Electricity Authority, during July, for power-station, transforming-station and transmission-line equipment amounted, in the aggregate, to £18,912,000. The principal contracts included: For Belvedere power station, Kent: Two generator transformers, with HACKBRIDGE AND HEWITTIC ELECTRIC CO., LTD. For Rugeley "A" power station, Staffordshire: Three 60,000-kW turbo-generators, with C. A. PARSONS & CO. LTD., four 550,000 lb. per hour boilers, with BABCOCK AND WILCOX LTD., and two condensing and feed-heating plants, with HICK, HARGREAVES & CO., LTD. For Agecroft "B" power station, Salford: One 120,000-kW turbo-generator, and condensing and feed-heating plant, with the METROPOLITAN-VICKERS ELECTRICAL CO. LTD., and two 860,000-lb. per hour boilers, with INTERNATIONAL COMBUSTION LTD. For Blyth "A" power station: Four 860,000-lb. per hour boilers, with BABCOCK & WILCOX LTD. For West Weybridge substation: 275-kV switchgear, with A. REYROLLE & CO. LTD. For Marchwood substation, near Southampton: 132-kV switchgear, with the BRITISH THOMSON-HOUSTON CO., LTD. For Pyestock substation: Two 60-MVA transformers with the METROPOLITAN-VICKERS ELECTRICAL CO. LTD. For Velmore substation: Two 45-MVA transformers, with the FULLER ELECTRICAL AND MANUFACTURING CO. LTD. For Rayleigh substation, Essex: 132-kV switchgear, with A. REYROLLE & CO. LTD. For Chadderton substation, Oldham: 132-kV switchgear, with the METROPOLITAN-VICKERS ELECTRICAL CO. LTD. For Ipswich (Cliff Quay) substation: 132-kV switchgear, with the METROPOLITAN-VICKERS ELECTRICAL CO. LTD. For Hams Hall "B" and "C" substations: 132-kV switchgear, with A. REYROLLE & CO. LTD. For Capenhurst substation, Cheshire: 132-kV switchgear, with the ENGLISH ELECTRIC CO. LTD. An 132-kV overhead transmission line from Carmarthen Bay to Trostre Tee, with RILEY & NEATE LTD.

THORIUM AS A SOURCE OF POWER

A SELF-MAINTAINING NUCLEAR FUEL

The future use of thorium as a nuclear fuel for power production was considered in a paper presented by Dr. J. V. Dunworth before the International Conference on the Peaceful Uses of Atomic Energy on Tuesday, August 9. In particular, Dr. Dunworth examined the possibilities of reactor systems, employing thorium and its associated fission nucleus uranium 233, which would be self-maintaining; such systems would produce as much fuel as they consumed. He also dealt with systems in which there would be a slight gain in fuel turnover. It has been suggested that chemically and metallurgically a thorium-uranium 233 system is preferable to a system using uranium 238 and plutonium. The paper, which was entitled "The Possible Rôle of Thorium in Nuclear Energy," is published here in slightly abridged form.*

HOMOGENEOUS AND HETEROGENEOUS SYSTEMS

This paper is concerned primarily with the practical result that a thermal-fission homogeneous reactor system fuelled with thorium and uranium 233 is likely to be about self-maintaining in fissile material, and that it might be possible to make a system with a small gain factor. The exact value of the gain factor will be determined by economic considerations associated with the engineering and processing plant design, but it will be assumed that, at the very most, this gain factor will not exceed 10 per cent. (that is on the average 1·1 atoms of uranium 233 are usefully recovered for each atom of uranium 233 which is consumed). However, it should be stressed that in practice this figure may not be reached.

In the case of a heterogeneous reactor employing solid thorium fuel elements containing uranium 233, it may be possible to have a system which is just self-maintaining. It should not be assumed, however, that thorium would not be used if the gain factor proved to be slightly negative by, say, 5 per cent. In this case, feeding an atom of uranium 235 or plutonium to a system should permit the burning of very roughly 20 atoms of thorium.

It is probably too early to be certain, but the general indications are that, both metallurgically and chemically, the thorium-uranium 233 system is to be preferred to the uranium 238-plutonium system.

One possible procedure is to build natural or slightly enriched heterogeneous uranium reactors and after extracting about 3,000 MW-days of heat per ton from the fuel, to re-arrange the fuel in the reactor so that part of the new charge consists of plutonium extracted from the spent fuel, and thorium. In this way the fertile material in the reactor would consist mainly of thorium for all except the first one or two charges, while the fissile material would be primarily uranium 233 soon after. However, as already indicated, a small and continuing feed of plutonium might be needed. This plutonium could be made by having a small section of the reactor operating permanently on a feed of natural uranium.

In the case of homogeneous reactors the design may well be appreciably different, depending on whether interest is in the plutonium-uranium 238 fuel system or the thorium-uranium 233 fuel system. If, as seems likely, the latter is chosen, it may be highly inconvenient to start with a feed of plutonium. In this case uranium 233 might be extracted from a heterogeneous reactor to provide the feed. Alternatively, uranium 235 must be made available from a diffusion plant.

KILOWATTS PER FISSILE KILOGRAM

When allowance is made for material in processing plants, a realistic rating in a heterogeneous pile probably lies between 0·1 MW and 1·0 MW of electrical capacity per kilogram of fissile material present in the fuel. In the case of a heterogeneous pile in which there is a fissile core these ratings might be exceeded in the central core, but when the hold-up of fissile material in the blanket material surrounding the core is taken into account, the previous statement is still probably more or less correct.

At the present time, Britain has 20,000 MW of installed electrical capacity and this is being increased at the rate of 2,000 MW per annum. If, as a rough estimate, a figure of one-third of a megawatt of electrical capacity per kilogram of fissile material is assumed, then six tons of fissile material would be required per year as initial charges if all new capacity were to be thorium nuclear power stations using thorium fuel. It is this factor and no other which is the reason that the use of thorium in heterogeneous reactors is likely to develop slowly.

In the case of a homogeneous reactor, somewhat higher overall ratings may be possible, but even here it is difficult to imagine a rating exceeding one megawatt of electrical capacity for each kilogram of fissile material in the system, when the material in the blanket is considered. In this case, the United Kingdom would need two tons of fissile material per year as capital investment.

U.K. THORIUM NEEDS

If it is assumed that after irradiation in a pile thorium is recovered in the processing plants for further use, then the whole of the United Kingdom electricity consumption would involve the purchase of only 15 tons per annum. Fortunately for the supplier of thorium, however, an initial stock in the reactor is necessary.

For the heterogeneous reactor, one is not likely to exceed ratings of perhaps 2 MW of electricity per ton of thorium and even this is probably high when account is taken of material in processing plants. The United Kingdom would therefore need at least 1,000 tons of thorium per annum for its new construction if all new electricity stations were nuclear powered and thorium fuelled, and, in practice, this figure might well be appreciably exceeded.

For a homogeneous reactor system, the thorium investment might be less than the figures given above for a heterogeneous reactor, but this is far from certain.

NEGATIVE AND POSITIVE GAIN FACTORS

A system with a negative gain factor of, say, 5 per cent. obtains 95 per cent. of its energy from thorium and 5 per cent. from either plutonium or uranium 235. Either proposal involves utilising only a small fraction of the atoms in natural uranium. In the one case, extraction of plutonium from a thermal reactor involves rejection of uranium earlier than would otherwise be necessary, while use of a diffusion plant similarly involves employing only a very few of all the atoms present in natural uranium.

For the sake of argument the ideal figure of 100 per cent. utilisation of uranium 235 will be assumed in the latter case. This means that only one atom in 140 in natural uranium will be consumed. On this assumption and a 5 per cent. negative gain factor, seven times as much natural uranium is required as thorium, assuming processing losses in thorium are small compared with the amount of thorium converted to uranium 233 in the reactor between each processing. Using the figure given above of 15 tons of thorium per annum actually consumed in supplying the entire electricity demand in Great Britain, the uranium requirement is 105 tons per annum. Even if only 25 per cent. of the uranium 235 were extracted in the diffusion plant and the negative gain factor of the reactor for thorium-uranium 233 were 10 per cent., the uranium requirement is still only 840 tons per annum.

If fast breeder reactors are in operation, then the uranium requirement is avoided, since fissile material can be transferred from the fast reactors to the thermal thorium-fuelled systems.

NEGLIGIBLE BREEDING

It has been suggested that it might be possible to secure a positive gain factor using thorium-uranium 233 and that this could possibly be as much as 10 per cent. With the rating given above for a homogeneous reactor, the life cycle of uranium 233 is approximately one-third of a year, and in this case the stock of fissile material could double roughly every two and a half years. In practice a time scale of four years, or even much longer, is probably more realistic. The period would be 40 years or more if it were necessary to produce several tons of fissile material by breeding from a small initial investment of a few kilograms, with a four-year doubling cycle.

Breeding with a thermal homogeneous reactor does not therefore seem likely to be of importance in providing the initial charges for building up quickly a chain of such reactors. It is just possible the gain factor would be sufficient for providing the initial charges subsequently when coping with the natural expansion of the electricity supply.

Another point is that it does not appear that the breeding gain, if any, is likely to be sufficiently large for the excess fissile material produced to alter significantly the economics of a reactor system even in the next 15 years when fissile material for civil use may have a scarcity value. It will be seen, therefore, that achieving a positive gain factor with a thermal thorium system is not likely to be of crucial importance.

THORIUM A MORE VALUABLE FUEL THAN URANIUM

The use of thorium on an appreciable scale in the United Kingdom is associated with tens of tons of fissile material being available. When this situation arises it is likely that thorium will be a more valuable fuel even than uranium. Achieving a positive gain factor with a thorium-uranium 233 system is not likely to be of crucial importance; a small negative gain factor can be tolerated.

It is important to note that the numerical data given in this report are highly speculative since no practical operating figures on full-scale reactors are available to the author. It is not believed, however, that present uncertainties are such as to alter the general conclusions made in the paper.

* * *

WIND POWER IN HAITI

A survey has recently been made in Haiti to determine to what extent the power in the wind can be converted to useful power. Haiti has only meagre sources of power, and the winds often come in the disastrous form of hurricanes; it is hoped that the winds may be made to compensate to some degree for the damage they so often cause. Mr. E. W. Golding and Mr. A. H. Stodhart have been to Haiti at the government's request under the United Nations technical assistance programme, and have set up ten wind-measuring stations. Observations will be taken over a period of a year or two, and then it will be possible to decide which are the best sites for wind-driven machinery. In addition to wind-driven electric generators, wind-power can be used in many places to pump water from supplies which exist at no great depth.

To follow the results of the wind-power survey, a wind-power committee has been established in Haiti on the same pattern as similar groups functioning in Great Britain, Denmark, France, India and Israel. It includes representatives of government departments and of the international organisations which are helping to promote Haiti's agricultural and industrial development. Through this committee it is hoped to ensure that practical steps will be taken.

* Reactor Physics Division, Atomic Energy Research Establishment, Harwell.

NUCLEAR POWER IN BRITAIN

SIR JOHN COCKCROFT CONSIDERS FUTURE DEMAND AND SUPPLY

Progress in nuclear technology in the United Kingdom has now reached the stage when it can be applied to the production of electrical power on a large scale, and the Government has decided to undertake a ten-year initial programme for the construction of nuclear power stations (ENGINEERING, vol. 179, page 240, 1955). *It is therefore of special interest to examine the extent to which nuclear power will supply energy needs in Britain during the next ten or twenty years, and even until the end of the century. In a paper entitled "The Contribution of Nuclear Power to United Kingdom and World Energy Resources up to 1975," presented before the International Conference on the Peaceful Uses of Atomic Energy on Wednesday, August 10, Sir John Cockcroft, K.C.B., C.B.E., F.R.S.,* outlined various factors in the application of nuclear energy to power production and considered its use in relation to Britain's future power needs. The following article is a slightly abridged version of Sir John's paper.*

UNITED KINGDOM PROGRAMME

The first nuclear power station in the United Kingdom is being built at Calder Hall by the Industrial Group of the Atomic Energy Authority and will derive its heat from two graphite-moderated reactors; the heat will be transferred to steam generators by carbon dioxide gas under pressure. This power station is expected to deliver over 50 megawatts of electricity to the National grid. It is illustrated below.

The output and efficiency of the graphite-moderated nuclear power stations can be increased by raising the pressure and temperature and improving the heat-transfer characteristics. Industrial organisations are now engaged on designing such improved power stations with technological help from the Atomic Energy Authority. The British Central Electricity Authority expect to build twelve of these power stations for successive completion between 1960 and 1965. The output of a single power station is expected to rise from 100 megawatts to at least 200 megawatts. The total installed capacity should therefore exceed 1,000 megawatts by 1965, by which time nuclear energy will be doing the work of several million tons of coal each year.

After 1965, when industry has gained experience in the construction of these stations, and the Electricity Authority in operating them, the programme is expected to expand much more rapidly, until by 1970 most of the new British power stations should be of the nuclear type. By 1975 the installed capacity is likely to have risen to between 10,000 and 15,000 megawatts, and the total capacity of the public electricity supply system would be then between 55,000 and 60,000 megawatts. The nuclear power stations will probably be operated as base-load stations and so will supply a higher proportion of the power in relation to their capacity than coal stations. Thus by 1975 nuclear power should be doing the work of at least 40 million tons of coal a year—providing about 40 per cent. of the energy for electricity.

A rough estimate of United Kingdom electrical power requirements for the year 2000 can be obtained by projecting forward current and estimated curves of demand, and they may then be forecast as the equivalent of about 250 million tons of coal. Probably the whole of the additional energy above 1975 requirements will have to come from nuclear sources. We can therefore expect nuclear power to be doing the work of from 150 to 200 million tons of coal by the year 2000 in Britain.

WORLD ENERGY REQUIREMENTS

This can be compared with world requirements in the year 2000 which have been forecast at 9,000 milliard units (9×10^{12}); this would require the use of 3½ milliard tons of coal equivalent a year if it were produced solely in thermal power stations. It has also been estimated that the total demand for primary fuel will be not less than 7½ milliard tons of coal equivalent a year. When these figures are compared with the available reserves of conventional fuels including hydro-electricity, the question arises whether it will be practicable for the greater part of the electricity demand—say 2 or 3 milliard tons of coal equivalent a year—to be met by nuclear energy.

The requirements of nuclear fuel for this task depend on the efficiency of utilisation of the fission energy of uranium. If a 33 per cent. utilisation could be obtained, one ton would do the work of 1 million tons of coal. It is anticipated that this high efficiency will be approached by successive steps in the development of nuclear power stations.

EFFICIENT USE OF FUEL

The graphite-moderated reactors with which Britain proposes to start its nuclear-power development have the great advantage of being able to use natural uranium fuel—they do not need supplies of enriched uranium from a diffusion plant. With these reactors it is expected that in a single fuel cycle the heat equivalent of at least 3,000 megawatt-days per ton of uranium will be extracted, yielding the heat equivalent of 10,000 tons of coal of normal British quality. This heat-extraction limit is expected to be determined by the deterioration of fuel elements rather than by nuclear factors.

At the end of the first cycle the fuel elements contain a substantial amount of plutonium together with fission products. The fission products will be extracted chemically and the uranium and plutonium can then be recycled. Alternatively, the plutonium can be used as a feed to other types of thermal reactors—such as water-moderated reactors requiring enriched fuel, or fast breeder power reactors such as that at Dounreay.

It has been shown that it should be possible to recycle uranium plus plutonium fuel several times until the concentration of uranium 235 has been reduced to a low figure and an appreciable amount of uranium 238 has undergone fission. In this way it may be possible to increase the heat extraction per ton of uranium from the equivalent of 10,000 tons of coal to as much as 100,000 tons.

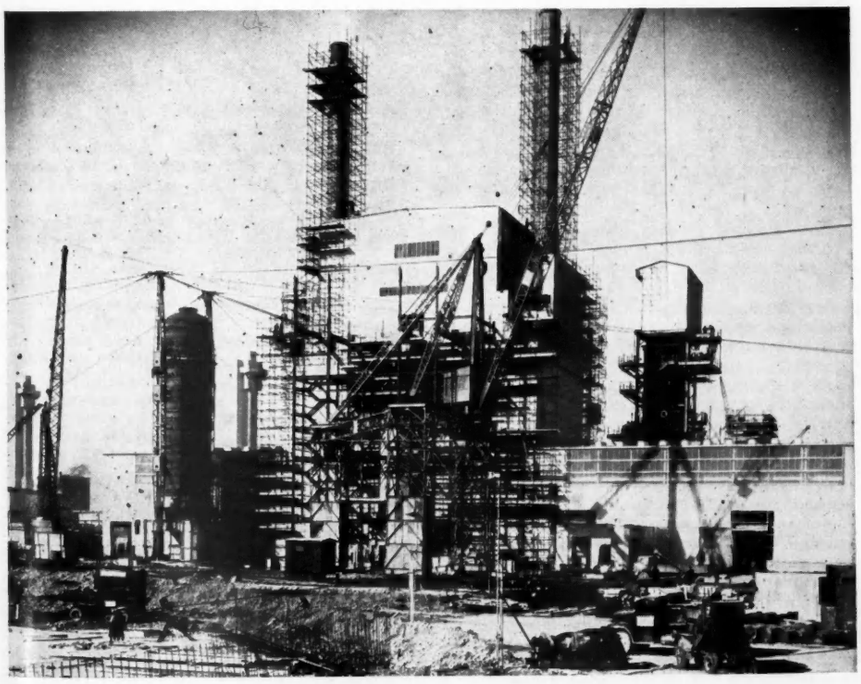
During this period and even earlier the type of reactor used in Britain is likely to change to one giving a higher rating and output. Water-moderated reactors now under study in the United Kingdom show considerable promise as possible successors to graphite-moderated reactors. Power outputs are likely to rise to at least 150 megawatts per reactor and capital costs are likely to fall to below £90 per installed kilowatt.

FAST BREEDER REACTORS

Still further improvement in uranium utilisation may be expected when fast breeder power reactors come into full-scale operation. Results obtained with the Harwell Zero-Energy Fast Reactor—Zephyr—show that plutonium fast reactors should have a very high gain factor. The secondary plutonium fuel bred in the reactor from uranium 238 should be substantially greater than the plutonium which undergoes fission in the core. It ought therefore to be possible to make use of the greater part of the fissile energy not only of uranium 235 but also of uranium 238, and to extract from one ton of uranium the heat equivalent of at least the million tons of coal mentioned earlier. Fast breeder reactors have thus an important long term interest in a nuclear power programme and in another paper (page 280 of this issue) the engineering problems of the large-scale experimental fast breeder reactor being built in Britain will be outlined.

The nuclear-power programme therefore promises improvements in uranium utilisation of two factors of ten as development proceeds. These technological improvements are likely to be achieved more rapidly than the expansion of demands for nuclear power. We can therefore envisage the United Kingdom nuclear-

* Director of the Atomic Energy Research Establishment, Harwell.



Britain's first nuclear power station at Calder Hall, Cumberland, begun in May 1953, is nearing completion. A heat exchanger can be seen, and in the background the 400-ft. chimneys of the Windscale factory.

power requirements for 1975 being met by an annual consumption of uranium of between 40 and 400 tons, together with initial requirements for new power stations which might exceed 400 tons per annum.

ADEQUATE URANIUM SUPPLIES

The possible United Kingdom requirements in the year 2000 for the equivalent of 250 million tons of coal a year would be met by burning 250 tons of uranium or thorium a year if breeding is by then fully developed. At the same period the emerging shortage in world supplies of the conventional fuels might be met by producing the greater part of world electricity supplies in nuclear power stations which would consume 2 or 3 thousand tons of uranium or thorium a year for the purpose. There would also be large additional requirements of uranium for initial investments in new reactors. Other papers, presented to the Conference, dealing with uranium supplies, suggest, however, that there should be little difficulty in meeting these requirements.

* * *

REACTORS AT HARWELL

Research for the Future

Nuclear research in the United Kingdom is centred on the Atomic Energy Research Establishment at Harwell, under the direction of Sir John Cockcroft. Harwell's primary role is to carry out long-term research and to act as a source of ideas for reactors and processes, but it is also responsible for considerable development work. Harwell has four atomic piles or reactors and is building three more; the first two, Gleep and Bepo, provided information for the first production piles of the United Kingdom Atomic Energy Authority's Industrial Group. All seven reactors are listed below.

Gleep (Graphite Low Energy Experimental Pile) is rated at 100-kW and has been in continuous use since 1947. It contains 505 tons of graphite, 12 tons of uranium metal and 21 tons of uranium dioxide.

Bepo (British Experimental Pile O) has been in continuous use since 1948, and contains 300 tons of graphite in 25,000 blocks forming a 26-ft. cube. Its full uranium load is 40 tons, and its heat rating 6,000 kW.

Zephyr (Zero Energy Fast Fission Reactor) began operation in 1954. It is the first fast reactor to be built in the United Kingdom. It is fuelled with rods of plutonium and has a core the size of a top hat. Fast reactors can produce more fuel than they burn.

Dimple (Deuterium Moderated Pile Low Energy) is the first heavy-water pile to be completed in the United Kingdom. It is extremely simple and thus a flexible experimental tool, and consists of a large aluminium tank filled with heavy water and surrounded by a graphite reflector. Canned uranium rods are hung in the tank.

Zeus (Zero Energy Uranium System) has a rating of 100 watts and is expected to be in operation this year. It is an uncooled fast reactor and is a full-size model of the Dounreay plant (page 280). It has a large highly enriched uranium core with a natural uranium blanket.

Dido (E.443, see ENGINEERING, August 19, page 235) is a high-flux research reactor of 10,000 kW, and is to be completed by the summer of 1956. It is a heavy-water reactor and will have the highest neutron flux of any in Western Europe. It will be used for a variety of experimental purposes including tests of fuel and coolant systems.

Pluto (R.E. 775) is a high-flux materials-testing reactor of 10,000 kW rating and construction has already begun. It will be of the same basic design as E.443, and each of its six test loops will provide a pilot model of the essentials of a future reactor system.

Book Reviews

THE SCOPE OF DIESEL ENGINES

Diesel Engine Principles and Practice. Edited by C. C. POUNDER. *George Newnes, Limited, Tower House, Southampton-street, London, W.C.2.* (84*s*.)

The range of the application of the modern compression-ignition engine covers the whole field from the large slow-speed marine engine to the smallest high-speed engine used by the model engineer, and each type presents its own particular problems resulting in a very wide scope for the designer.

The spark-ignition engine design was to a certain extent based on the experience of the steam engine, and evolved into a much more stereotyped design because of the more critical conditions prevailing in the engine cylinder than in the steam engine. Higher standards of workmanship, better materials, and new processes of machining appeared, and these not only have made possible the high standard of performance and reliability exhibited by the modern petrol engine, but have been of considerable benefit to engineering production as a whole.

The design of the high-speed compression-ignition engine has in its turn demanded still higher standards of production especially in the manufacture of injection equipment and in bearing alloys, not to mention the many other items contributing to the excellence of the modern design. However, there is a wider range in the form taken by the design than in the case of the petrol engine, not only in the constructional sense but also in the theoretical cycle which may be adopted.

The cycle finally adopted by Diesel assumed that the combustion of the fuel occurred under constant-pressure conditions, the injection of the fuel being adjusted at the correct rate to obtain this. Large low-speed engines secure this theoretical ideal reasonably closely and when the dimensions of the cylinder are large it is obviously an advantage to the designer to limit the maximum pressure to that necessary to provide the compression temperature needed to promote the combustion of the fuel. Since most compression-ignition engines operate on a cycle approximating more closely to the constant volume cycle, the purist would agree that they are not Diesel engines. It is perhaps a pity that our nomenclature includes "semi-Diesel," "dual combustion," "high-speed Diesel," and so on, and the term diesel (without the capital) is now often used to signify that the engine compresses air only, and relies on the temperature of the air to provide the ignition of oil fuel, the flash point of which is normally sufficiently high to present no fire risk in handling or storage.

The volume *Diesel Engine Principles and Practice* covers the complete range of types mentioned above, and comprises 26 chapters, each written by an expert in his own particular field. Although this sub-division is bound to result in a certain measure of discontinuity, the fact that many considerations are common to several chapters and are authoritatively dealt with from a slightly different point of view, assures that all aspects have been completely presented, and the reader is left with a balanced impression.

There is a reasonable amount of theory included, particularly in the treatment of the ideal thermodynamic cycles, exhaust gas turbo-charging and the mechanical considerations of balancing and of torsional vibration, but this is only enough to justify the considerable amount of descriptive matter which forms the major part of the work. It is relatively an easy matter to deal with engineering problems either purely theoretically or purely descriptively, but the application of theory to practice is much more difficult to achieve, and this balance has been struck in a praiseworthy manner by the editor. It may be that in some chapters the temperatures are quoted in Fahrenheit and in others in Centigrade, but most engineers are sufficiently bi-lingual not to raise an eyebrow over such matters, nor to query the particular units which may have been adopted by the different authors.

The marshalling of the considerable and diverse information, and the choice of the contributors, obviously requires an editor having a true and comprehensive perspective, and no better choice could have been found for this office than in Mr. C. C. Pounder. Mr. Pounder has seen the large marine Diesel grow from a somewhat dubious proposition to its present-day reliability and efficiency, and he himself has been to a very large extent responsible for this development. He is a director and the chief engineer of Messrs. Harland and Wolff and clearly regards the Diesel engine with real affection. He has not only been responsible for the planning of the book, but has contributed several sections himself, one of particular importance being on the causes and prevention of crankcase explosions. The basic thermodynamics and the general theoretical treatment have been ably presented by Dr. A. F. Burstall, who is Professor of Mechanical Engineering at the University of Durham. As would be expected from a name which is as well known in commercial circles as in the academic field, this section is a balanced blend of theory and practice. A relatively long contribution has been made by Mr. C. B. Dicksee on the development of engines for vehicles. He holds a world-wide reputation as an authority on all problems related to this class of engine and has presented numerous papers to all the chief engineering institutions.

Another name immediately springs to mind, that of Mr. R. Stansfield, whose research on combustion for the (then) Anglo-Iranian Oil Company, Limited, did so much to develop, amongst other things, the cathode-ray indicator. His contribution deals with fuel and combustion and this is complemented by a section on oils and lubrication by Mr. J. C. Withers, who worked with and later took over the duties of Mr. Stansfield on his retirement.

The modern development in turbo-charging and the problems related to scavenging are covered by Mr. R. W. Stuart Mitchell and Mr. A. J. Penn, the former being the Chief Development Engineer for the English Electric Company, Limited, and the latter being the Chief Engineer of the Gas Turbine Division of Messrs. D. Napier and Son, Limited. Although space will not allow the inclusion of the names of all the contributors, each of whom is an expert in his own particular field, special mention must be made of Mr. E. Molloy who has a very wide experience in the compilation of technical publications. He has been responsible for the sections dealing with fuel-injection systems and starters, and the illustrations and descriptions give a very complete presentation of the present design. Throughout the treatise the choice of illustrations and the preparation of the diagrams are a credit to all concerned and make the whole volume readable and not a dry-as-dust book of reference.

From the designer's point of view there are chapters on heat exchangers, scavenge and exhaust systems, and transmission systems, in addition to full descriptions of injection systems, governors, starters, and other auxiliary equipment. There are separate sections dealing with fuel and combustion, lubrication and the metallurgy of bearing metals and other metals concerned with design.

There are 848 pages with 580 illustrations and diagrams, a comprehensive index, and most chapters give bibliographical references at the end. The whole is a reference book which should find a place in the library of the engineering college, the design department, and in the personal references used by the professional mechanical engineer.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in ENGINEERING.

Long Lake Dam and Main Canal: Technical Record of Design and Construction. *Bureau of Reclamation, United States Department of the Interior, Denver, Colorado.* (No price given.)

The Long Lake Dam is one of the major structures on the Columbia Basin irrigation system, raising the water surface by 90 ft. Long Lake will not be operated as a storage reservoir but will permit the water to be delivered to canals at a much higher elevation than could otherwise have been achieved. The main body of the dam is a moistened and rolled embankment of clay, sand and gravel, with the outer sides covered with rockfill. Well illustrated by drawings and photographs, the book is a complete record of the design and construction of the dam.

Pest Infestation Research, 1954. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (3*s.*)

This pamphlet of 54 pages constitutes the report of the Pest Infestation Research Board for the year 1954. Much of the report deals with the control of various insect pests in stores of wheat and other foodstuffs by the use of fumigants and insecticides. Liaison on problems of food storage with the Colonial territories is shown to be very active. Visits of agricultural and storage officers are exchanged and food-storage courses for officers from Colonial territories are held by the Ministry of Agriculture and Fisheries.

Carbon Monoxide. Methods for the Detection of Toxic Gases in Industry, Leaflet No. 7. Third edition. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (9*d.*)

This pamphlet describes the conditions of occurrence of carbon monoxide, its poisonous effects, methods of detecting it and instructions on carrying out the test and safety precautions to be adopted, during it. The standard test method is the same as that given in the previous (1950) edition. The sections dealing with the occurrence and poisonous effects have been re-written in consultation with the Factory Department of the Ministry of Labour and National Service, the Medical Research Council, the Ministry of Supply, and the Association of British Chemical Manufacturers.

Aircraft Control—A Survey. By W. TREVARTON TRUSCOTT. *The Association of Engineering and Shipbuilding Draughtsmen, Onslow Hall, Little Green, Richmond, Surrey.* (3*s.*)

In this 68-page pamphlet, the author reviews the problems of aircraft control, mainly in non-mathematical terms, under the following headings:—the human pilot; the simple flap, covering lift, drag and hinge moment, tab effect, control force and fixed and variable circuit gearing; lateral control—ailerons, slats, boundary layer fences, adverse yawing moment, differential action, spoilers, wing warping, rotating wing tips, elevons, etc.; longitudinal control—elevators, inverted slats, elevons, adjustable tail-planes and V-tails; directional control—rudders, vertical tail stalling and rudder lock, spinning, movable fins; control reversal; control balance—aerodynamic, tab and mechanical balances, mass balance and flutter; trim—fixed trimmers, adjustable trimmers, tabs, all-moving surface controls, variable camber, datum change control mechanisms, trim actuators, automatic trimming; the manually-operated circuit—push-pull controls, torque-tube circuit, cables, system combinations; and servo control—servo tabs, power assisted controls, fully power-operated controls, duplication. The book includes a bibliography of nine references. It is illustrated by line diagrams.

The Commonwealth and Nuclear Development. Central Office of Information Reference Pamphlet No. 2. *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.*)

This booklet, issued to coincide with the International Conference on Peaceful Uses of Atomic Energy, tells the story of the development of atomic energy in Britain and Commonwealth countries. A chapter on the development of fundamental theory up to 1939 is followed by an account of the war-time and post-war work on atomic weapons. The third chapter deals with the organisation of the United Kingdom atomic energy project. The pamphlet concludes with descriptions of progress in the Commonwealth countries and recent developments in international co-operation.

Mastering Momentum. A Discussion of Modern Transport Trends and their Influence upon the Equipment of American Railways. By LEWIS K. SILLCOX. Second edition. *Simmons-Boardman Publishing Corporation, 30 Church-street, New York 7, N.Y., U.S.A.* (No price given.) (Reviewed on page 201, in the issue of August 12.)

Elementary Surveying. By WILLIAM HORACE RAYNER and MILTON O. SCHMIDT. Third edition. *D. Van Nostrand Company, Incorporated, 250 Fourth-avenue, New York 3, N.Y., U.S.A.* (5.50 dols.); and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.*2. (38*s.*)

This book has been written to meet the needs of (*a*) first-year courses in surveying and mapping for civil-engineering students; (*b*) an elementary course in surveying for students in technical schools; (*c*) a course suitable for students of geology, geography, forestry and agriculture; (*d*) general courses for non-civil-engineering students in engineering colleges. Intended as a text-book for use in class-work, the treatment has been kept as brief as is consistent with clarity and completeness. It also contains chapters on land surveying, including a historical note on the development of the United States public lands system.

Aircraft Power Plants. By the Technical Development Staff of the Northrop Aeronautical Institute. Revised edition. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (8 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.*4. (60*s.*)

This book is one of a series of three textbooks designed to encompass information on all phases of operation and maintenance of American airframe and power plant. After a brief historical introduction, it covers internal-combustion engine principles; fuel and fuel systems for aircraft; float-type and pressure-injection carburettors; supercharging and induction systems; aircraft-engine classification and construction; lubricants; engine-starting systems; ignition systems; valve and ignition timing; engine control systems; propeller fundamentals, inspection, maintenance and repair; the principles of jet propulsion; uses of the gas turbine; modern (American) turbojet engines; and jet engine systems, operation and inspection.

Studies of Boundary Value Problems. Part II: Characteristic Functions of Rectangular Plates; Part III: Oblique Plate in Oblique Co-ordinates. By SVEN T. A. ODMAN. *Swedish Cement and Concrete Research Institute, Royal Institute of Technology, Stockholm.* (Part II, 35 kr.; Part III, 5 kr.)

In Part II of *Studies of Boundary Value Problems*, the author develops solutions for the characteristic functions of plates in natural vibration, covering plates simply supported at two opposite edges; at all edges; at two opposite edges and built-in at the other edges; at two opposite edges and free at the other edges; plates built-in at all edges; and the free rectangular plate. In Part III, he discusses the treatment of oblique plates by using oblique co-ordinates, following a recapitulation of Favre's derivation by a deduction of the strict homogeneous boundary conditions of the plate. He demonstrates that the expression for the strain energy of the plate is one of the components of the expression for the internal work of the plate derived from its differential equation. Finally, the expressions for the cross-sectional moments and forces are deduced in directions parallel to and perpendicular to the edges.

* * *

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Flour and Provender Milling Machinery. THOMAS ROBINSON AND SON, LIMITED, Railway Works, Rochdale, Lancashire. The Company manufacture a complete range of machinery for the flour and provender milling industries, and the equipment described covers the whole of the processes involved, from cleaning and separation to roller-milling, dressing and conveying. Sieving, scouring, brushing, stoning, damping, sifting, screening, purifying and grinding machines are described and illustrated, together with auxilliary equipment such as bin dischargers, dust collectors, bleachers, sack chutes and roll grinding and fluting machines. Specifications as well as descriptions and illustrations are given on a separate data sheet for each machine. A useful feature is the provision of "planning-in" drawings given overall dimensions. Stiff loose-leaf binder, with space for adding new data sheets as issued.

Woodworking Machinery. THOMAS ROBINSON AND SON, LIMITED, Railway Works, Rochdale, Lancashire. Machines suitable for all types of woodworking, from log band-saws to joinery and pattern-making equipment are described and illustrated in eight main groups. The principal machines dealt with are: band-saws, circular saws, planers and moulders, panel planers and thicknessers, vertical spindle moulders and mortisers, saw sharpening and doctoring machines, cutter grinders, and special-purpose machines such as sleeper adzers and borers. Illustrated catalogue with thumb-index.

Chemical Plant. BRITISH CHEMICAL PLANT MANUFACTURERS ASSOCIATION, 14 Suffolk-street, London, S.W.1. 1955 edition of Association's directory entitled *British Chemical Plant*, containing lists of members of the Association and illustrated description of their main products and services. A classified index of these products and services is furnished and also a French, German and Spanish key to the classified index.

Projection and Photographic Lamps. BRITISH THOMSON-HOUSTON CO., LTD., Rugby. Lamps for projectors and other photographic applications from 10 to 10,000 watts and 4 to 250 volts. Also electronic and photoflash lamps and compact source mercury lamps. Illustrated catalogue L985 gives full list and also list of recommended types for over 3,000 different cine projectors.

Electrically-operated Valves. ELECTRO-HYDRAULICS LTD., Liverpool-road, Warrington, Lancashire. Electrically-operated hydraulic valves for all types of liquid, tested up to 9,000 lb. per sq. in. Standard, flameproof, intrinsically safe, corrosion-resistant and relay types, and electro-hydraulic actuator. Catalogue also includes flow charts and nomograms.

Silver Brazing Alloy. JOHNSON, MATTHEY & CO., LTD., Hatton-garden, London, E.C.1. Easy-flo "paint" consisting of a mixture of finely-divided Easy-flo silver-brazing-alloy powder and flux in a liquid medium. A paste preparation for brazing a wide range of materials; it can be used with any of the various methods of heating in general use. Data sheet 2129 containing detailed instructions.

Mud Hog Crushers. BRITISH JEFFREY-DIAMOND LTD., Stennard Works, Wakefield. Heavy duty single direction mud hogs for crushing all kinds of wet sticky material; for example, a combination, of lump and wet slack coal containing a small percentage of sticky clay, used in power plants. Illustrated pamphlet.

Compressors and Jointing Equipment for Overhead Transmission Lines. TATE BROS., LTD., 100 Old Shoreham Road, Portslade, Sussex. Descriptions of the compressors for jointing overhead electric transmission lines in the field. Details of joints, cable cutters, fairleads sagging wheels and other accessories. Illustrated leaflets.

Protective Systems. A. REYROLLE & CO., LTD., Hebburn, Co. Durham. List of the protective systems available for electrical networks and apparatus. Brief details to facilitate quick and easy reference, which can be supplemented by full descriptive pamphlets.

Electric Motors. BROOK MOTORS, LTD., Empress Works, Huddersfield. "Keep Your Motors Running," abridged version of volume on installation and maintenance of electric motors published some time ago. Covers motor construction, maintenance, powers and circuits. (1*s.*)

Harmonic Distortion Meter. ROCKE INTERNATIONAL CORPORATION, 13 East 140th-street, New York, 16, N.Y., U.S.A. A Heath kit of parts for constructing a harmonic distortion meter with a frequency range of 20 to 20,000 c/s. Accuracy within 5 per cent. of full scale reading. Leaflet.

Electric Motor Speed Controller. PRECISION HEATING, LTD., 142A Canbury Park-road, Kingston-on-Thames. Infinitely variable electric-motor speed controller for fractional horse-power motors up to 1 h.p. Speed range 30 to 1 at approximately constant torque. Illustrated leaflet.

Nevitron Rectifiers. NEVELIN ELECTRIC CO. LTD., Purley Way, Croydon, Surrey. Mercury-arc rectifier equipment incorporating Nevitron single-anode tubes for three, six and twelve-phase rectification or as three-phase bridge-connected units. Illustrated pamphlet contains technical details.

Aluminium Alloys in Textile Industry. HIGH DUTY ALLOYS LTD., Slough, Buckinghamshire. Light-alloy bobbins for the textile industry; their manufacture and testing. Illustrated descriptive catalogue.

Selecting a Lift Truck. HYSTER CO., 2902 N.E. Clackamas-street, Portland 8, Oregon, U.S.A. How to select a fork truck. Evaluation of features and analysis chart. Leaflets 1411 and 1406.

OIL TRANSFER AND COOLING IN RING-OILED BEARINGS—1

By N. Özdaş, PH.D., *and Professor H. Ford*, D.SC.(ENG.), PH.D., M.I.MECH.E., M.I.C.E.

One of the problems in the realisation of thick film conditions in hydrodynamically lubricated journal bearings is the method of oil supply. If a continuous fluid film is to be maintained and the load-carrying capabilities are to remain unimpaired, sufficient lubricant must be fed to the entry side of the bearing both to compensate for end leakage and to dissipate the heat generated by viscous shear in the oil film.

Although force-feed systems have become very popular in recent years, the ring-lubricated bearing has distinct advantages: it is extremely simple and reliable, depending for its efficient action upon no external pump, drive or pipework; it shows great oil economy, as well as being very cheap to manufacture and maintain; there is also a small, but none-the-less important, saving in power over forced-feed lubrication systems.

The use of ring-lubricated bearings is restricted to stationary horizontal journals but, within this limitation, the above advantages are so distinct that a more exact assessment of their application seems timely. It is generally considered that oil rings should only be used for slow-speed shafts but with proper design they have been used in high-speed machines and even in steam turbines of up to 500 h.p. they have proved successful.

In thick film lubrication, when the relative moving surfaces of a bearing are separated from each other by lubricant, the heat generated from shearing the oil film causes the temperature both of the film and of the bearing to rise. Increasing temperature has the effect of reducing oil viscosity and augmenting the heat dissipation from the housing and both effects tend to bring the temperature to a steady condition. The operation of a bearing in this region of thermal equilibrium is stable and the characteristics of operation depend on such factors as surface finish, clearance, etc.

However, if the viscosity decreases still further until the point of minimum coefficient of friction is reached, boundary lubrication may then start and the operation may become unstable because from that point onwards the coefficient of friction will increase as the viscosity decreases, leading to increasing heat generation with further rise of temperature and so on until failure occurs.

In force-feed bearings, heat is dissipated not only from the bearing housing by conduction, convection and radiation, but by the oil itself acting as a coolant. In ring-oil bearings, any heat taken away in the oil is fed to the bearing sump only and must again be dissipated from the housing. The thermal and hydrodynamical characteristics of ring-oiled bearings are therefore closely connected, and a knowledge of the temperature distribution in the load-carrying film is of great importance.

A study of published papers on ring-oiled bearings revealed, with a few notable exceptions, very little exact information on their action and performance. In this research the oil transfer and heat dissipation characteristics of ring-lubricated bearings have been investigated with a view to assessing their capabilities and possibly extending their field of application.

EQUIPMENT FOR OIL TRANSFER EXPERIMENTS

The first object of the investigation was to measure the oil transfer to a shaft under various conditions, using otherwise geometrically similar systems. No bearing surrounded the shaft, the oil transferred by the ring being collected in a scoop specially designed to simulate a bearing.

The arrangement is shown in Fig. 1. Three steel journals, 75 mm., 100 mm. and 125 mm. diameter were used, being keyed in turn to a shaft mounted in ball bearings and driven by a motor, the speed being continuously variable from 30 to 2,000 r.p.m. A sheet steel casing, with a glass window in the front held the oil into which the ring dipped and a head tank maintained a constant level of oil in the oil casing throughout the test. The oil collected in the scoop was led out through the side of the casing and could be measured. For the tests at different temperatures, a thermostatically controlled heater was immersed in the casing. The temperature was accurately measured and controlled.

The characteristics of the two oils are given in Table I and Fig. 3.

Table II and Fig. 2 give details of the test rings, these dimensions being such as to give a wide range of proportions.

Grooved rings were also tested, using a ring of the same standard dimensions as for the 100-mm. journal (Figs. 2b and 2c). Later, a special ring 160 mm. inside diameter, 15 mm. square section was made with one groove into which a scraper could be fitted so that the oil could be collected. This is shown in Fig. 2(*d*).

From a study of rings used in practice, the proportions of the rings for the similarity tests were fixed as follows:

—	Standard Dimensions
$\frac{\text{Inside diameter of ring}}{\text{Journal diameter}} = \frac{D}{d} = 1{\cdot}60$	D = 160 mm
	d = 100 mm.
$\frac{\text{Ring thickness}}{\text{Inside diameter}} = \frac{t}{D} = \frac{1}{32}$	b = 15 mm.
$\frac{\text{Ring width}}{\text{Inside diameter}} = \frac{b}{D} = 0{\cdot}1$	t = 5 mm.

TABLE I. *Characteristics of Test Oils*

—	Test Oil No. 1		Test Oil No. 2	
Type of oil ..	Spindle oil (naphthenic base)		Machine oil (paraffinic base)	
Specific gravity ..	0·889		0·886	
	Redwood, secs.	Kinematic viscosity centistokes	Redwood, secs.	Viscosity centistokes
Viscosity at				
70 deg. F.	120	29·2	416	102·7
140 deg. F.,	44	7·1	75	17·0
200 deg. F.,	34	3·1	43	6·5
Thermal conductivity cals. per deg. C. per sec. per cm.: *				
At 32 deg. F.	0·00031		0·00031	
At 212 deg. F.	0·00029		0·00029	
Surface tension, dynes per cm.	31		31	

* Suppliers data.

TABLE II. *Dimensions of the Test Rings*

Journal diameter, *d* (mm.)	30	55	70/75	100		125	150	250	
Ring inside diameter, D (mm.)	55	90	120	150, 160, 165, 170, 180		200	240	390	
Ring width, *b* (mm.)	8	12	12	8, 12, 15		16·5	18	21	
Ring thickness, *t* (mm.)	3	4	4	3·75, 5, 15, 7·5		6	6	7	
Slot width in scoop (mm.)	12	16	16	20		22	24	28	
Materials ..				Mild steel Brass Aluminium					

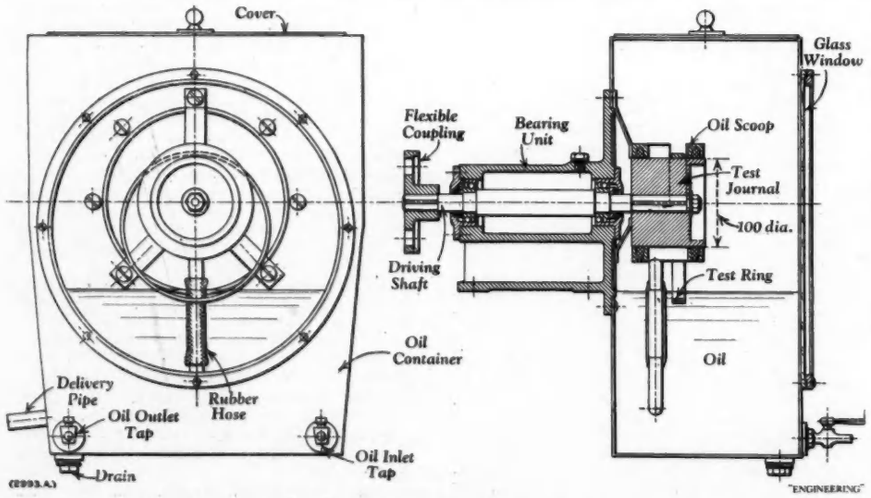


Fig. 1 The equipment used for the oil transfer tests, showing the 100 mm. test journal in position and the test ring.

TEST PROCEDURE

Tests were made with a dry ring and journal and then with the ring immersed to various depths in the oil bath, the journal speed being varied over the greatest range possible. The tests were repeated with the various journals, rings, materials, and oils, at oil temperatures from 14 to 55 deg. C.

When steady conditions had been reached, the oil from the scoop was collected in a measuring flask for a given time interval The journal speed was measured by tachometer, the ring speed by counting the revolutions of a white mark on the side of the ring, observed through the window. A "Strobolux" was used at higher speeds, particularly for the tests with the ring and journal dry.

During the course of a test, heat is generated and the oil becomes warm to the extent of two or three degrees centigrade, depending in a complicated manner on time and speed. While every effort was made to maintain steady temperature, these variations could not be entirely eliminated and to minimise their influence tests were made both starting at a low speed and increasing to the highest speed and also starting at a high speed and decreasing to the lowest.

The oil level was controlled by a fine scale fixed on the glass window.

RESULTS OF RING SPEED TESTS

With a ring and shaft assembly, clean and dry (devoid of all lubricant), the "Strobolux" showed the slip to be under 1 per cent. even with a shaft speed of 1,500 r.p.m. Rings only slightly contaminated with oil gave the same result.

Figs. 4 and 5 show the relationships between

ring speed and shaft speed for various immersions for test oils No. 1 (light) and No. 2 (medium), respectively.

The mechanism of operation with a low viscosity oil can be described as follows: at very low speeds, the ring has the same peripheral speed as the journal; this is the solid friction region and there is no slip. The extent of this region depends on viscosity, surface finish, geometry of the ring and grooving (for grooved rings) and on the pressure between ring and journal. As the speed increases, the ring slows down relative to the no-slip speed and a region of boundary friction commences. After a minimum has been reached, the speed steadily increases as a viscous film

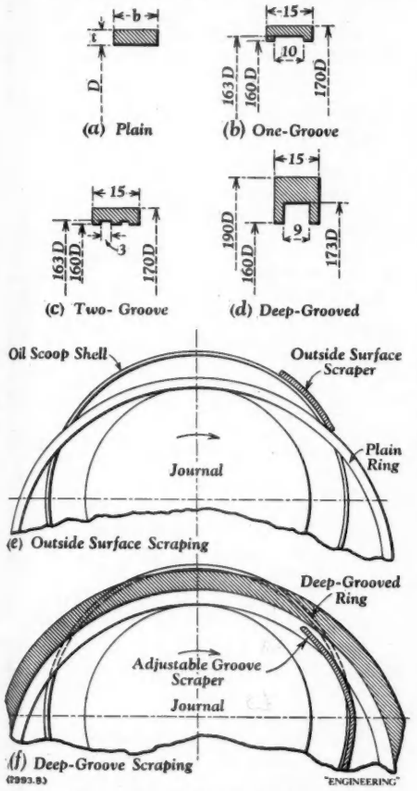


Fig. 2 The rings used in the tests were plain or grooved in a variety of ways as shown in Figs. 2 (b), 2 (c) and 2 (d).

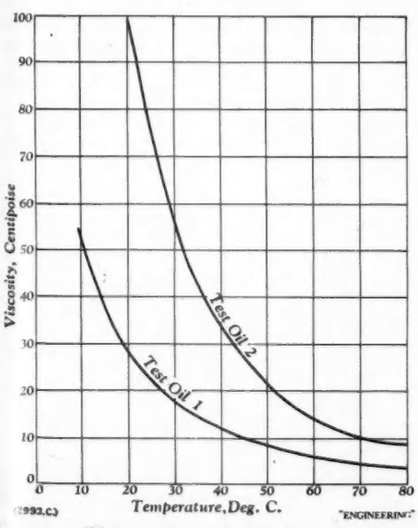
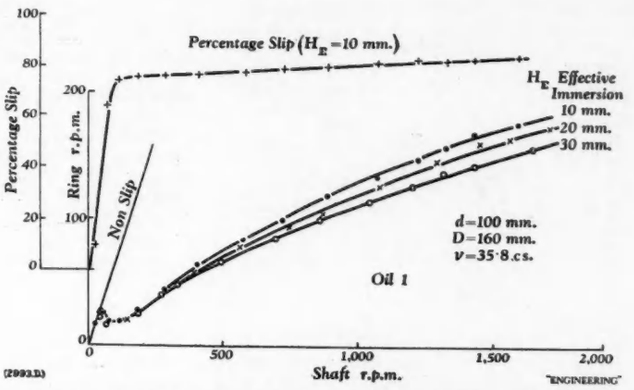


Fig. 3 The two oils used in the tests showed considerable difference in their change of viscosity with temperature.

Fig. 4 Relation between ring speed and shaft speed when using oil 1 for various depths of immersion; the top curve shows the percentage slip against shaft speed when the ring is immersed 10 mm.



begins to build up between the journal and the ring. Over the whole of this range, the slip increases only slightly.

With oil of higher viscosity, the initial stages described above do not occur, slip being present from the lowest speeds and there is no minimum in the curve. The slip has a high value from the start and does not change seriously over the whole speed range. It is to be noted that the slip is less with the more viscous oil.

RING IMMERSION

The depth of immersion of the ring in the oil-bath has an important effect both on ring speed and oil delivery. Fig 6(*a*) shows typical test results, in which the immersion was varied while maintaining the journal speed constant. Increase in immersion slows down the ring and the oil delivery decreases at the same time, so long as the whole ring cross-section is immersed. Figs. 6(*b*) and 6(*c*) show the results for two different sizes of ring, where, as the immersion is decreased, a point is reached when a sharp fall in oil delivery occurs. This critical immersion corresponds to the point where the oil is detached from the inner surface of the ring. It is seen that the normal immersion differs from the actual immersion by an amount which depends mainly upon surface tension effects, but also to a lesser degree upon speed and viscosity. When the inner surface is freed of oil, the viscous drag of the immersed surface is much reduced and the ring increases its speed considerably. Consequently, the oil adhering to the sides and outer surface is thrown off owing to the increased centrifugal force. This, and the fact that the inner surface of the ring is by far the most effective in transferring oil, accounts for the sudden drop in oil transfer.

It is concluded, therefore, that it is important that the immersion should be not less than the critical immersion, particularly in the higher-speed journals. The oil delivery results are given below in terms of the effective immersion, from which the normal immersion H_N can be found by adding the thickness of the ring $H_N = H_E + t$.

The critical value of H_E was found to be about 6 to 8 mm., the higher value being for higher speeds and viscosities. For practical considerations, the effective immersion should probably be from 10 to 15 mm. (say, $\frac{3}{8}$ in. to $\frac{5}{8}$ in.) to ensure complete immersion at all times, but Fig. 6 shows that a higher immersion is inefficient and unnecessary.

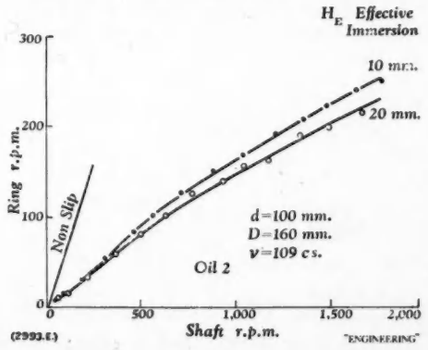


Fig. 5 Relation between ring and shaft speed using oil 2, of higher viscosity. Slip is less with the more viscous oil.

EFFECT OF SPEED ON OIL TRANSFER

Typical curves of oil delivery for the two oils at two different immersions are shown in Fig. 7. With the low viscosity oil (No. 1) the oil delivery increases linearly at first, in step with the linear increase in ring speed (this region is most clearly seen in Fig. 8) until the sudden rise in slip occurs, when there is a decrease in oil delivery, giving a first minimum. Further increase in speed increases the oil delivery: the oil film attached to the ring is stable in this region, but at about 400 r.p.m. (with this journal and ring assembly) the first discrete oil drops began to be thrown off owing to centrifugal force. This happened at a clearly defined speed, and another decrease in oil delivery occurred as the speed was increased beyond this point. If this region is passed through quickly, the second minimum

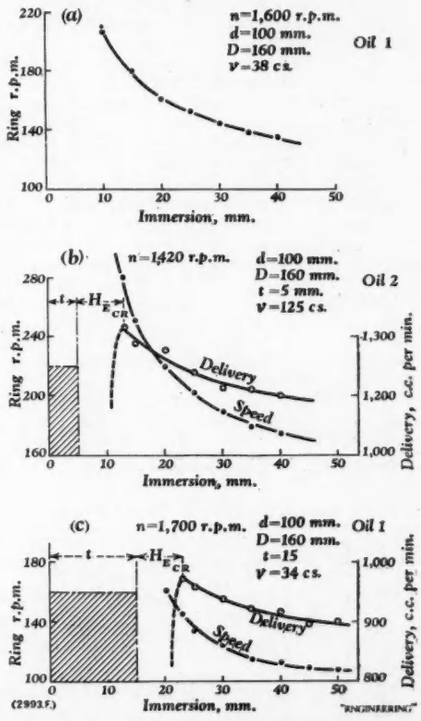


Fig. 6 (a) Shows the relation between immersion and ring speed for certain conditions. Figs. 6 (b) and (c) show the relation between immersion and ring speed and delivery for different shaft speeds and oil viscosities. The critical point where oil delivery falls is very clear.

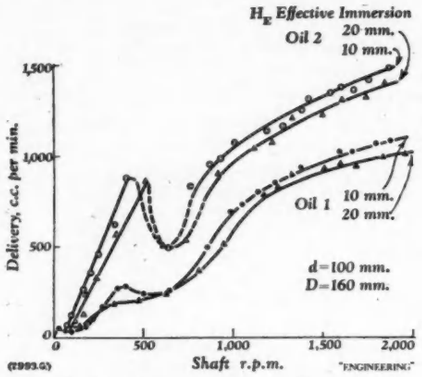


Fig. 7 Oil delivery against shaft speed for different immersions and oils.

is not observed. Beyond the critical region the oil delivery again increases steadily with journal speed.

The higher viscosity oil does not show the first minimum because slip occurs from the beginning, but the centrifugal effect is even more marked, the oil delivery falling immediately even without further rise in speed. A definite curve could not be obtained between 500 and 750 r.p.m. As the ring speed is a function of ring dimensions, the second minimum occurs at lower journal speeds the thinner the ring and the larger the journal diameter (see below).

EFFECT OF SURFACE FINISH AND SHAFT DIAMETER

Results for a roughly turned ring and a polished one are compared in Fig. 8. For the low viscosity oil, the solid friction region extends over a greater speed range for the rough ring than the polished ring and the oil delivery is correspondingly higher. However, after the first minimum, the difference in ring speeds and deliveries becomes negligible, and the curves coincide at higher speeds. With the more viscous oil, no significant difference was found in ring speed or oil transfer with the rough finish.

Fig. 9 shows typical results for oil delivery with different journal diameters, in which the ratio of ring diameter D to journal diameter d was held constant. A direct comparison is not possible, however, because for practical reasons, the other dimensions (width and thickness of ring) could not be kept geometrically similar. There were small variations as follows:

Journal Diameter (mm.)	75	100	125
$\frac{D}{d}$ ratio	1·6	1·6	1·6
$\frac{t}{D}$ ratio	1/30	1/32	1/30
$\frac{b}{D}$ ratio	1/10	1/10·5	1/12·1

The important ratios are $\frac{D}{d}$ and $\frac{b}{D}$, but these factors will be discussed later.

EFFECT OF RING DIMENSIONS

Diameter.—Experiments with a 100 mm. diameter journal and rings of 150, 160, 170 and 180 mm. inside diameter were made, the cross-section being kept constant at 15 mm. wide by 5 mm. deep. As the diameter increased, the slip increased and the oil transfer was slightly reduced, but the differences are smaller the higher the journal speed. These facts can be deduced from Fig. 12.

Thickness.—The ring speed decreases with increase of thickness for a constant ring diameter. The advantage gained by the increase in thickness is lost by the slowing down of the ring, because centrifugal force throws away the small additional amount of oil adhering to the sides of the ring.

Width.—The inner surface of the ring is the most important surface for oil transfer. Calculations made with the collected data indicate that the oil delivery increases approximately as the square of the width for a constant Reynolds number, although the ring speed decreases with increase in ring width for a given thickness, as might be expected in view of the development of a fluid film between ring and journal.

Ring Material.—Tests with identical rings of brass, mild steel and aluminium show the importance of the density of the ring material. To ensure a reliable comparison, the three rings were tested successively without changing the journal speed. The brass and mild steel rings, having nearly the same density give about the same delivery of oil, but the aluminium ring rode with considerable eccentricity on the journal owing to the counter balance of the oil film on the rising side: the eccentricity became so great that the inner surface rubbed against the collecting scoop and the oil was scraped off the inner surface even after cutting away the slot still further. The use of light metal rings must therefore be avoided in ring-oiled bearings.

The slip in the viscous region is also greater for a light ring, and in turn the mild steel ring showed slightly greater slip than the brass. The hydrodynamic formula for coefficient of friction is in line with this finding

$$\mu = K\sqrt{\frac{\eta v}{p}},$$

where μ = coefficient of friction;
η = viscosity of the oil;
v = linear relative velocity between journal and ring;
p = load per unit length;
K = a constant.

the quantities being expressed in appropriate units.

The effect of the temperature of the oil is seen in Fig. 10. Tests were made with oil No. 2 at various temperatures from 18 deg. C. to 55 deg. C. and both the ring speed and oil delivery decrease considerably with rising temperature. This more viscous oil had the same viscosity at 38 deg. C. as the lighter oil (No. 1) had at room temperature, and the oil delivery curve for the latter is superimposed on Fig. 10. There is close agreement between the two results, showing decisively that viscosity is the only important property of an oil as far as oil transfer is concerned.

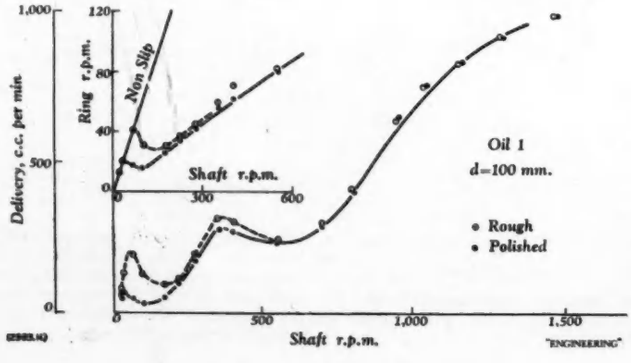


Fig. 8 The effect of surface finish; oil delivery and ring speed for rough and polished rings.

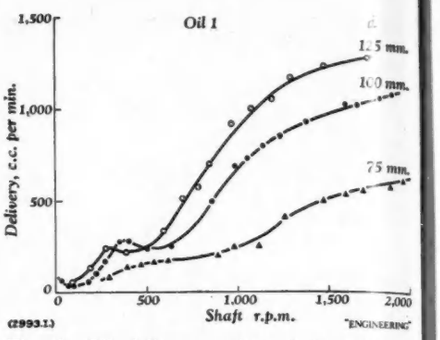


Fig. 9 Oil delivery against shaft speed for different journal diameters; the ratio of ring diameter to journal diameter was held constant in all cases.

GROOVED RINGS

A few tests were made with grooved rings of the types shown in Fig. 2, and the oil transfer performance was recorded. At a given journal speed in the lower speed range, grooved rings have higher speeds and deliver more oil than the equivalent plain ring. The solid friction (nearly non-slip) region is longer and the oil delivery increases rapidly. At higher speeds, boundary conditions prevail and a thin film of oil can be formed between journal and ring.

The single groove ring has a performance inferior to that of the plain ring at high speed, probably owing to the centrifugal effect throwing the oil to the inside of the grooving. However,

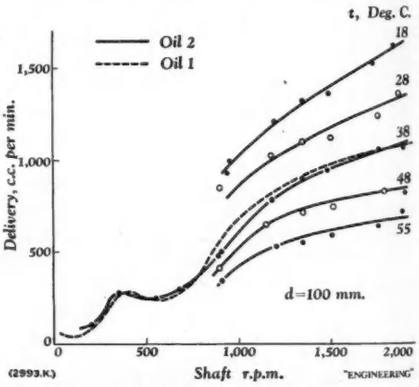


Fig. 10 The effect of oil temperature; oil delivery against shaft speed for different oil temperatures, showing that delivery is greater when the oil is cooler.

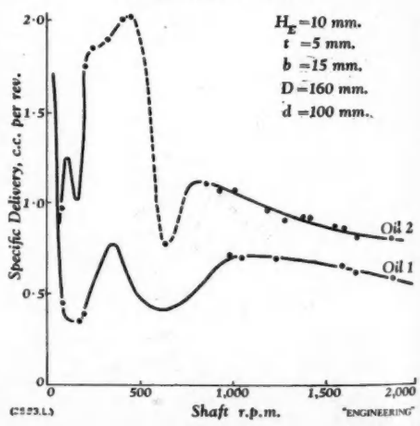


Fig. 11 The specific oil delivery—oil delivered per revolution of the shaft—plotted against shaft speed, shows a much higher transfer of the more viscous oil.

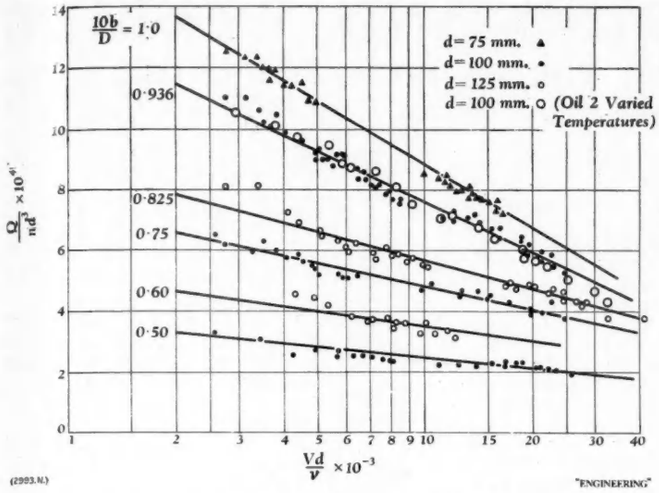


Fig. 12 $\frac{Q}{n d^3}$ plotted against the logarithm of the Reynolds number for varying values of $\frac{10\,b}{D}$ where b is the ring width and D is the inside diameter of the ring.

the double groove ring has a better performance than either presumably because the higher speed compensates for the centrifugal effect and the meniscus also is such that the groove runs full. The advantage of grooving is largely lost even with the double groove ring at really high speeds.

Additional tests were made on a deep groove ring, in which the inner surface was scraped. This was very effective in increasing the oil transfer. A smaller advantage is found when the outer surface of a plain ring is scraped, at least at low speeds, but at high speeds this was most effective. In this case, the oil transfer increased with depth of immersion in contradistinction to the earlier tests in which the surface was not scraped. Such a scraping device presents no difficulty, the friction between the ring and journal being sufficient to overcome the small resistance offered by a lightly spring-loaded strip near the crown of the bearing.

DIMENSIONAL ANALYSIS OF OIL TRANSFER

For geometrically similar systems, the oil transfer would be expected, for reasons of the forces acting on the ring, to depend upon:

some linear dimension of the system, e.g., the journal diameter d [L];
V = the linear velocity [LT⁻¹]
η = the viscosity of the oil, at the test temperature [FTL⁻²]
ρ = the specific gravity of the oil [FT²L⁻⁴]
γ = the surface tension [FL⁻¹]

The density of the ring material has been omitted, because it does not change much with commonly used materials.

The quantity of oil delivered per revolution, q, should be dependent upon the above variables, If Q is the quantity of oil delivered per minute by a ring to the journal rotating at n revolutions per minute, then

$$q = \frac{Q}{n}\ [L^3]$$

and

$$q = F\left\{d, V, \eta, \rho, \gamma\right\}.$$

Applying dimensional analysis and choosing the appropriate variables, we get:

$$\frac{Q}{n d^3} = F\left\{\left(\frac{\rho V d}{\eta}, \frac{\gamma}{\eta V}\right)\right\}$$

and, in the general case, where the ring dimensions are varied

$$\frac{Q}{n d^3} = G\left\{\left(\frac{\rho V d}{\eta}\right)\left(\frac{\gamma}{\eta V}\right)\left(\frac{D}{d}\right)\left(\frac{b}{D}\right)\left(\frac{t}{D}\right)\right\}.$$

$\frac{Q}{n d^3}$ is called the specific delivery and the first group $\frac{\rho V d}{\eta}$ is the equivalent of Reynolds number. The second group contains the surface tension, which varies with specific gravity and temperature. The surface tension does not vary much when the temperature is essentially lower than the critical (i.e. that temperature at which the surface tension vanishes—about 300 deg. C. for lubricating oils) and is roughly given by the empirical expression

$$\frac{\gamma}{(\rho_e - \rho_v)^4} = \text{a constant},$$

ρ_e and ρ_v being the densities of the liquid and gaseous phases respectively.

Calculations show that, for a temperature change from 30 to 60 deg. C., the surface tension changes only by 5 per cent. and accordingly the group $\frac{\gamma}{\eta V}$ will be neglected, so that

$$\frac{Q}{n d^3} = f\left\{\left(\frac{\rho V d}{\eta}\right)\left(\frac{D}{d}\right)\left(\frac{b}{D}\right)\left(\frac{t}{D}\right)\right\}.$$

The experiments covered a fairly wide range of these variables and should allow the possibilities to be tested. From a general study of the oil delivery curves, it was clear that a correlation could only be hoped for after the second minimum point where true thick film and stable conditions had been established. This study also suggested that the correlation would be valid from a ring speed of about 1½ ft. per second in the size of bearings examined although with the more viscous oil stable conditions are realised at lower speeds. The same variation also exists for variation in ring thickness: with a thick ring, correlation starts at a higher journal speed than with a thin ring.

Such conditions naturally limit the use of non-dimensional curves of specific deliveries, especially as in so many applications rings are used in slow speed bearings. There is no difficulty in operating a ring-oiled bearing at low speeds either as regards oil transfer or cooling, and under these conditions, the individual curves must be considered.

Fig. 11 shows how the specific oil delivery—that is, the oil delivered per revolution of the shaft—varies with speed. This illustrates the fact that the amount of oil transferred from the bath to the journal falls as the speed increases. With the low viscosity oil, the fall is rapid at first corresponding more or less with the ring speed variation. The flow then becomes steady for a time before a further trough occurs, but the flow finally levels off at about 0·6 c.c. per rev. up to the highest speed. The more viscous oil shows throughout a much higher transfer.

CORRELATION FOR DIFFERENT VARIABLES

Immersion and temperature.—From the graphs of oil delivery against shaft speed and against immersion, it is seen that the delivery varies with immersion, and temperature. However, by adopting the relative speed v = (shaft speed)—(ring speed) in the Reynolds number $\frac{\rho v d}{\eta}$, it is possible to correlate the results for different immersions. Fig. 12 shows $\frac{Q}{n d^3}$ plotted against log (Reynolds number) for various geometric arrangements, i.e., various values of 10b/D. In preparing this graph, allowance was made for the effect of temperature on viscosity with respect to the actual temperature at each set of readings. It is interesting to note that the results for the two oils correlate satisfactorily on the same graph where the viscosity was the same i.e., the test on the viscous oil at 38 deg. C. gave the same viscosity as in the light oil at 14 deg. C., see curve for $\frac{10\,b}{D} = 0{\cdot}936$. In general the points for the viscous oil lie to the left, the light oil to the right, but it is clear in all cases that the results lie on one curve for each value of 10b/D. The viscosity would therefore appear to be the only property of the oil which is involved in the oil transfer.

Ring Thickness.—The thinner the ring the higher the delivery, but the thick ring has a higher velocity, so giving a higher Reynolds number. The curves in Fig. 12 consequently have a negative slope, but all the results for different ring thickness correlate satisfactorily on this graph.

Ring Width.—Tests with rings having widths of 8 mm., 12 mm. and 15 mm. show the importance of the ring width in oil transfer. From Fig. 12 it can be estimated that for constant Reynolds number, the delivery varies approximately as the square of the width.

Ring Diameter.—In Fig. 12 only results for the same ratio of $\frac{D}{d}$ were included. It was found that the oil delivery was proportional to the square of the diameter ratio and the results for the tests with $\frac{D}{d} = 1{\cdot}5$, 1·6, 1·7 and 1·8 are shown in Fig. 13, the number $\frac{Q}{n d^3}$ being plotted against (Reynolds Number) $\times \left(\frac{D}{d}\right)^2$. The advantage of a small ring compared with the shaft diameter is, however, limited by the bearing design.

The second half of this paper will appear in a subsequent issue, and will deal with the heat transfer tests on ring-oiled bearings.

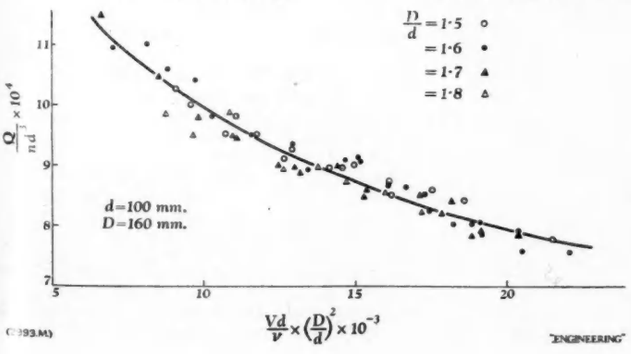


Fig. 13 $\frac{Q}{n d^3}$ plotted against Reynolds number multiplied by $\left(\frac{D}{d}\right)^2$ where D is the inside diameter of the ring and d is the journal diameter.

ENGINEERING, MARINE AND WELDING EXHIBITION

AND THE FOUNDRY TRADES EXHIBITION OLYMPIA, LONDON SEPTEMBER 1—15

First Article

The Engineering, Marine and Welding Exhibition, which was first held in 1906, only takes place every other year. This year it is to be held at Olympia, London, from September 1 to September 15, and with it will be the Foundry Trades Exhibition, an event which only occurs every fourth year. All the halls at Olympia will be used, giving an area of more than a quarter of a million square feet.

Over 1,000 products are listed in the catalogue, covering almost the whole field of engineering. The range of sizes is equally large. In 1953, visitors from over 60 countries attended and it is hoped that the coming exhibition will be even better supported. It is, of course, impossible to describe all the items displayed, but brief notes of some of them will be given in this and subsequent articles.

STEAM BOILERS

Exhibits being shown for the first time by Babcock and Wilcox, Limited, Farringdon-street, London, E.C.4, will include four items as follow. First is the company's "Steambloc" automatic oil-fired packaged boiler which is manufactured in evaporative capacities of 1,500 lb. to 18,000 lb. per hour (equivalent to 1·5 to 18 million B.Th.U. per hour for heating duty). On the marine side, a new exhibit will be a scale model of the "Selectable Superheat" boiler which enables a wide range of temperature control to be obtained with a single furnace design. This boiler was described in detail in our issue of August 12, on page 213.

Pneumatic operation of sootblowers—another innovation for the company—is featured alongside hydraulic and electrical operation in an exhibit emphasising the importance of cleanliness for obtaining maximum boiler efficiency and availability. This section of the stand will also include the Babcock shot-cleaning system (Broman-Ekstrom patents) for horizontal tube surfaces. "Spreader" firing is to be the subject of the fourth exhibit. This will be used to demonstrate how difficult fuels from various parts of the world can be burned successfully using spreader stokers. Other items on the stand will be displays illustrating the company's contributions to the nuclear-power programme, describing "Cyclone" firing, and a number of models of boilers of the types now being sold for installation in power stations and ships.

OIL-FIRED PACKAGED BOILER

The "Steambloc" packaged boiler, mentioned above, is being handled by a Babcock subsidiary, Spencer-Bonecourt-Clarkson Limited, 14-15 Fetter-lane, London, E.C.4. There are 12 models in the series having a range of evaporative capacities of from 1,500 lb. to 18,000 lb. per hour (from and at 212 deg. F.); the model to be on the stand is No. 120 in the series, having a capacity of 3,000 lb. per hour, though that shown in the illustration, Fig. 1, is a somewhat larger unit—No. 200—of 5,000 lb. capacity. Though primarily oil-fired units they can be supplied for gas firing.

The features of the "Steambloc" boiler are as follow: (*a*) it is a completely self-contained unit which incorporates all the auxiliary plant; (*b*) it is oil-fired, and automatic control ensures a high all-day efficiency; (*c*) a number of safety devices have been fitted in order to reduce the attention required; and fourthly (*d*) it requires no special boiler house or chimney stack as it is a forced-draught unit requiring only a rudimentary vent for the exhaust.

The boiler is of the three-pass "super-economic" type and efficiencies of over 80 per cent. are claimed for normal commercial operating conditions. The flue is partly corrugated and partly plain; the corrugated section increases the flexibility, thereby restricting the thermal stresses, and the plain cylindrical portion at the burner end ensures correct flame development. A two-fold advantage is obtained from the use of the comparatively small-diameter return tubes. Firstly, the high velocity of the gas causes the turbulence essential for maximum heat transfer. Secondly, the mechanical properties of the boiler structure are improved, since the small-diameter tubes not only allow wider and stronger ligaments in the tube plate, but are themselves more flexible and able to take up any unequal expansion due to the temperature difference between the second and third passes without the tendency to distortion of the tube plate (and consequent leakage) which might occur with stiffer tubes.

The boiler shell is covered with lagging and steel cladding to reduce heat losses, but access for tube cleaning and inspection is provided by a quick-release hinged door (also lined) at the rear of the boiler. A soot door in the front smoke chamber allows removal of deposits.

The burner equipment is of the pressure atomising type designed for dealing with heavy fuels up to bunker "C" grade, both steam and electrical pre-heating equipment being provided. The starting sequence is entirely automatic and in the event of any fault developing—e.g., the flame not burning—the control equipment shuts down the boiler. Full protection is provided against low water level, high steam pressure and flame failure (the flame is under constant observation of a photo-electric eye).

BOILER CLEANING

The importance of clean boilers for efficient operation can hardly be over-emphasised and a large display will be devoted to this question, including a new method of sootblower operation. The Babcock "Unidirectional" retractable sootblower, featured for the first time at the last Engineering and Marine Exhibition, is now available with pneumatic operation (in association with James Gordon, Limited, manufacturers of "Hagan" control gear). The "Unidirectional" blower is also to be shown with Babcock-BTH electrical operation and Babcock-Lockheed hydraulic operation.

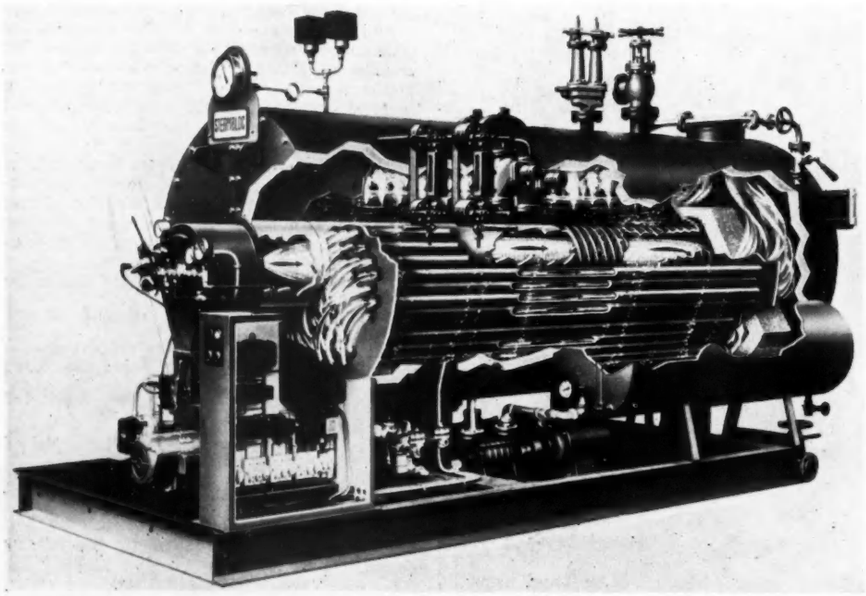


Fig. 1 The "Steambloc" packaged boiler. An oil-fired unit, it is completely self-contained and the built-in forced draught eliminates the need for a special chimney stack. Babcock and Wilcox, Ltd.

Exhibits Described

Steam Boilers
Oil-Fired Packaged Boiler
Boiler Cleaning *Babcock and Wilcox, Ltd.*

Diesel Engines and Motors
60-kW Induction Heater *English Electric Co., Ltd.*

Research as an Aid to Industry
Arc Welding Unit *Murex Welding Processes, Ltd.*

Diesel-Driven Distillation Plant
John I. Thornycroft and Co., Ltd.

Electric Furnaces and Gas Drying Equipment
Heat Treatment of Foundry Products *Birlec, Ltd.*

Servicing Fuel-Injection Systems
Merlin Engineering Co., Ltd.

Turbine Construction
Distribution Transformers
C. A. Parsons and Co., Ltd.

Multi-Motor Control Board
Welding Control Equipment
British Thomson-Houston Co., Ltd.

Ship's Telegraph *Chadburns (Liverpool), Ltd.*

350-kW Gas Turbine
Electrically-Driven Sewage Pumps
W. H. Allen & Sons and Co., Ltd.

Automatic Steering Gear
Depth Recorder *S. G. Brown, Ltd.*

High Tension Switchgear *George Ellison, Ltd.*

Pressure Vessels *G. A. Harvey and Co., Ltd.*

Fans *Keith Blackman, Ltd.*

Carbon Lined Pipes *Talbot Stead Tube Co., Ltd.*

Portable Thread Cutting Machine
Tube Cutter *Wright Electric Motors (Halifax), Ltd.*

Diesel-Engined Welder
Sigma Process *Quasi-Arc Co., Ltd.*

Projection Welder *Sciaky Welding Machines, Ltd.*

High Frequency Radio Telephone *Redifon, Ltd.*

Lightweight Hydraulic Presses and Croppers
Pilot Works, Ltd.

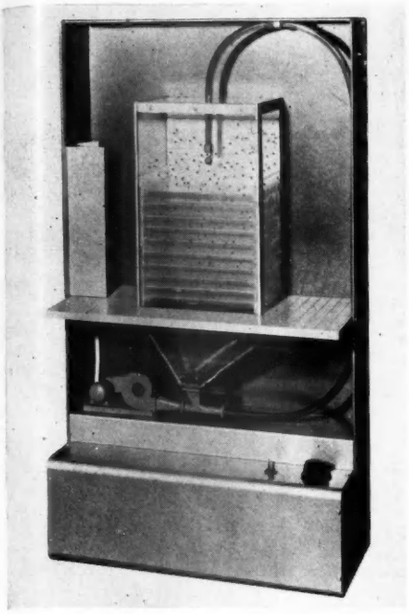


Fig. 2. Model showing the Broman-Ekstrom method of cleaning the outside of horizontal boiler tubes with metal shot. Babcock and Wilcox, Ltd.

Two other types of soot-blowers will be shown. First is the Babcock-Diamond unit, a small and simple hand-operated blower which has a long record of service for marine and small land-type water-tube boilers and secondly, by contrast, a large rack-type unit. This latter is intended for high-temperature zones where a retractable unit is essential and the travel required is very large (up to 25 ft.) The particular unit at the exhibition will be fitted for pneumatic operation.

A model, shown in Fig. 2, will demonstrate the operation of the Babcock shot-cleaning system (incorporating Broman-Ekstrom patents). This is a highly effective means of cleaning horizontal tube surfaces of boilers (e.g., air heaters, economisers, etc.) where the flue-gas temperature does not exceed the ash-fusion temperature. Operational costs are claimed to be less than 10 per cent. of those for an equivalent soot-blower installation, and operation involves no loss of condensate.

Small irregularly shaped metal shot is cascaded evenly from a distributor above the tube banks through which it is forced by the velocity of the furnace gases, thus dislodging the deposits in the early stage of their formation. The shot and deposit fall towards an inclined-screen separator where a controlled current of air returns the deposit to the gas stream, while allowing the shot to fall into a collector bin, from which it is returned to the distributor either pneumatically or by a mechanical conveyor. Frequency of operation depends on such factors as the boiler loading and nature of deposit. A typical cycle might involve operation every eight hours.

DIESEL ENGINES AND MOTORS

The English Electric Company, Limited, 28 Kingsway, London, W.C.2, will be exhibiting on three stands at the exhibition. On one of these the products of the Diesel engine division and the Industrial Motor department will be shown. These will include a 400-kW emergency generating station on wheels; an eight-cylinder pressure-charged marine Diesel engine and gearbox for installation in a cargo coasting vessel; and a 16-cylinder V-form Diesel engine for industrial traction and marine duties. Other activities of the division will be shown in model and pictorial form.

The Industrial Motor department will be showing a range of British standard dimensional totally-enclosed fan-cooled motors, the outputs of which vary from ½ to 25 h.p. The new protected N.E.M.A. dimensional motor, which is available in four frame diameters for horsepowers ranging from ½ to 25 h.p., will also be exhibited, as will a silent variable-speed fractional horse-power motor for washing machines.

60-KW INDUCTION HEATER

As regards welding equipment, a range of portable and multi-operator alternating-current machines will be displayed. The Industrial Electronics department will be showing the 60-kW radio frequency induction heater illustrated in Fig. 3. This will be operated in conjunction with a pin and bush hardening machine. As will be seen, the heater is housed in a sheet-steel cubicle with the components in vertical central panels. It is supplied with three-phase power at 360/440 volts, the consumption being 100 kW at full load and the power factor 0·9.

The oscillator consists of a valve which has been specially developed by the company for industrial use and which is cooled by an air blast. The three-phase full-wave rectifier circuit is made up of six mercury-pool units, which are grid-controlled and give a smoothly adjustable output from 0 to 12 kV. The oscillator valve filament and anode voltages are stabilised to give effective correction in 0·1 second on mains variations of ± 15 per cent.

The output of the heater on continuous duty is 60 kW at a frequency of 300 kilocycles, but an intermittent output of 75 kW at 80 per cent. of the duty cycle can be obtained.

The workpiece can be electromagnetically traversed through a work coil and at the same time spun and quenched, thus ensuring that a uniform amount of heat is applied to its surface area throughout the operation.

RESEARCH AS AN AID TO INDUSTRY

The central feature of the stand of Murex Welding Processes, Limited, Waltham Cross, Hertfordshire, will be an exhibit which will demonstrate a basic point in the metallurgy of steel—the transformation of its atomic structure which is associated with a temperature of 900 deg. C. Round this will be other displays to show metallurgical and physical testing, radiography, chemical and spectrographic analysis. A miniature machine will show how steel, which is tough and ductile at room temperature, can become brittle at sub-zero temperatures. For this purpose samples of the same material will be shown being fractured at room temperature and after freezing.

The welding equipment will include the new Murex "Dynex" brush-shift generator incorporated in a motor-generator set, although it can also be driven by Diesel or petrol engines. This generator, shown in Fig. 4 on page 274, allows the current to be infinitely varied irrespective of the power circuit voltage. It has been specially developed for arc welding, has drooping characteristics, and a current range of 15 to 300 amperes for continuous hand welding, while currents up to 450 amperes are available for intermittent work.

There are no series resistances, and the controls included consist of a voltage regulator, which is adjusted by a small knob, and a current regulator, which is operated by a cranked handle. A calibrated indicator plate eliminates the need for instruments. The absence of resistances and instruments also renders a control cabinet unnecessary and, in fact, the controls are built into the top of the end shield. The open-circuit voltage can be varied between 70 and 90 volts and remote control can be fitted. A polarity-reversing switch is included so that the welding leads can be permanently connected to the two output terminals.

ARC WELDING UNIT

The new transformer arc-welding equipment which will be shown, is a single-operator oil-cooled self-contained unit with a current range of 25 to 350 amperes for continuous hand welding and up to 450 amperes for intermittent work. It has four current ranges which are selected by a crank handle on the top of the transformer, and there are twelve current selections on each range. Space is provided for a capacitor so that the power factor can be corrected. There are two open circuit voltages of 80 and 100 volts, which are connected by a copper link to the "earth and work" terminal as required. The equipment, which is mounted on wheels and fitted with a drawbar, is suitable for connection to any voltage between 200 and 500.

Another exhibit of interest is the new rectifier

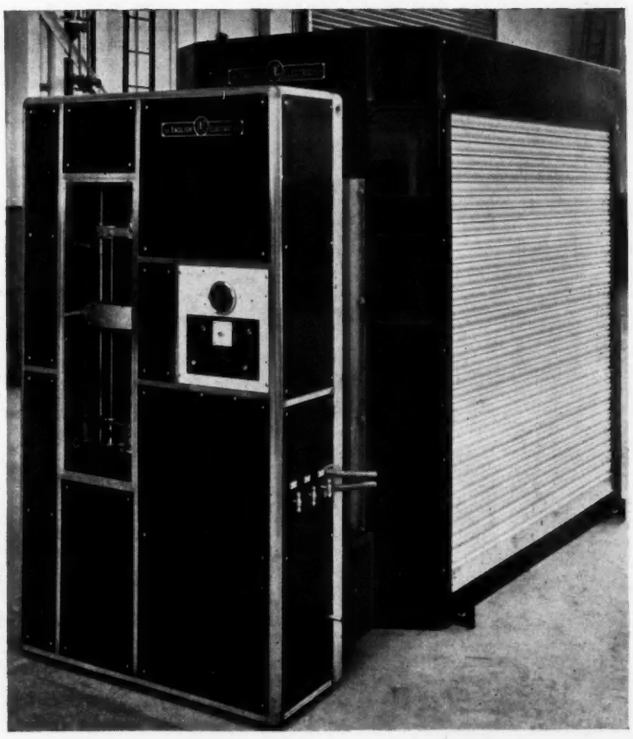


Fig. 3 60-kW radio frequency induction heater. The workpiece can be traversed and rotated electromagnetically. English Electric Co., Ltd.

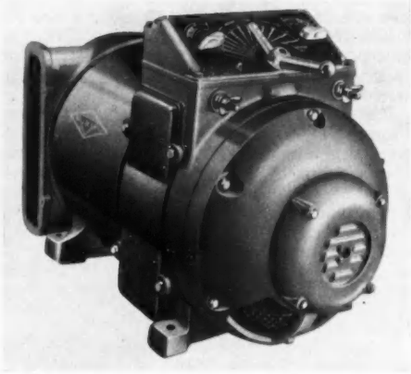


Fig. 4 300/400 ampere brush-shift generator for electric welding. This allows an infinite variation of current irrespective of the voltage. Murex Welding Processes, Ltd.

equipment which has a current range of 20 to 350 amperes for continuous hand welding. It is provided with forced-draught cooling and an interlocked safety switch. Remote control is available over the whole range. Finally, there will be an oil-cooled regulator for use with the firm's multi-operator transformers with open circuit voltages of 80 and 100 volts. Current selection is by means of two seven-way switches giving 49 positions altogether. The particular regulator shown is designed for a current-carrying capacity of 350 amperes, but 150, 250 and 450 ampere versions are also available.

DIESEL-DRIVEN DISTILLATION PLANT

John I. Thornycroft and Company, Limited, Thornycroft House, Smith-square, London, S.W.1, will be exhibiting marine Diesel engines, oil-operated gearboxes and oil burners. The engines will include the 30-h.p. RTR4, the 125-h.p. RZ6, the new 16-h.p. RJD/2 (see ENGINEERING, page 188, *ante*), and the industrial version of the last, known as the JD/2. This will be shown as the prime-mover of a distillation plant made by Buckley and Taylor, Limited, Castle Iron Works, Oldham, which is designed to produce drinking water from the sea or from stagnant supplies. It is shown in Fig. 5, the engine being on the right.

The operation of the plant is that the engine drives a vapour-compressor and also suction and delivery pumps, while at the same time heat is taken from its exhaust and cooling systems to boil the sea-water in an evaporator. The steam produced is compressed and returned to a steam chest in the evaporator where it helps to cause evaporation and is itself condensed. The feed water is heated in an exchanger by contact with the distillate and with the engine cooling water. Heat is also extracted from the oil in another exchanger. Steam generated by the passage of the cooling water over the engine exhaust is also fed to the evaporator. It is intended that the plant shall draw from a settling tank, but it can also draw direct from the sea if necessary, though in this case additional filters should be used. To prevent scaling in the evaporator, the feed is kept at a sufficient quantity to provide a steady overflow which keeps down the concentration of salts. The rate of operation is governed by the speed at which the engine is run.

ELECTRIC FURNACES AND GAS DRYING EQUIPMENT

The exhibits of Birlec, Limited, Tyburn-road, Erdington, Birmingham, 24, will be representative of the three main groups of products manufactured by the Company, which are for metal melting, heat treatment and gas drying. In the metal melting group the representative furnace will be a 35-kW Birlec-Tama unit of the low-frequency induction type for aluminium, zinc and alloys of these metals. It has a charge capacity of 500 lb. For humidity control of process gases ranging from compressed air to carbon dioxide, natural gas and nitrogen, the well-known Birlec "Lectrodryer" range will be represented by a model BY 1 standard dual adsorber unit with optional automatic change-over of cylinder duty.

HEAT TREATMENT OF FOUNDRY PRODUCTS

A new heat treatment furnace, the Birlec HRP, will be introduced at the exhibition. It is available in two standard sizes; 50 kW, with a charge space 4 ft. long by 2 ft. 6 in. wide and 1 ft. 6 in. high, and 70 kW, with dimensions of 5 ft. by 3 ft. by 1 ft. 6 in. The smaller furnace will be exhibited and is shown in Fig. 6.

The HRP furnace has been specially designed for dealing with heavy, bulky charges under dirty conditions, the charges being handled by unskilled labour if necessary. It is therefore of robust construction, with clean external lines. Temperature control to $\pm$ 10 deg. C. can be obtained over the working range of 700 to 1,050 deg. C. The nickel-chromium ribbon elements are in the arched roof of the heating chamber and in slots beneath the hearth slabs; there are no elements in the side walls. An additional heating element is fixed in the door brickwork, and is arranged to switch off and on automatically as the door opens and closes. The hearth is of high-grade alumina firebrick, chosen for its resistance to abrasion and spalling.

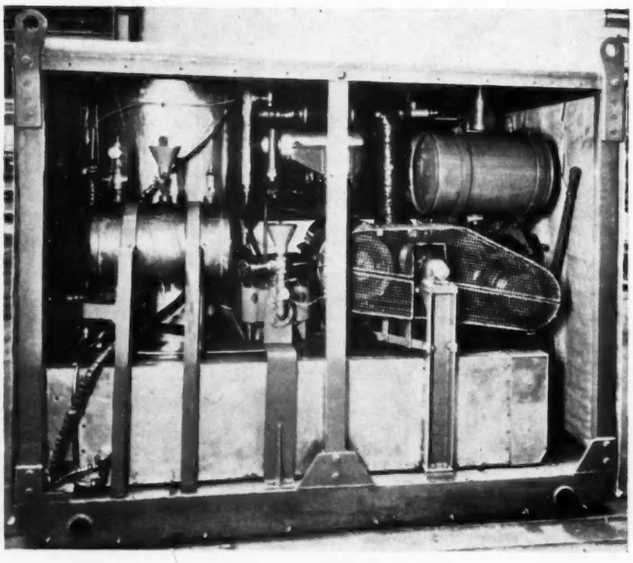


Fig. 5 Diesel-driven distillation plant. In addition to driving the pumps, the engine also acts as the heat source for the evaporator. John I. Thornycroft & Co., Ltd.

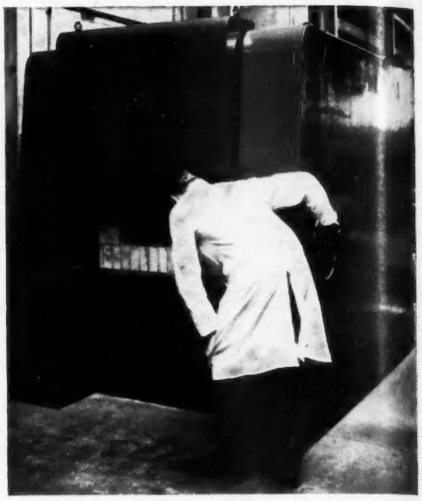


Fig. 6 The new Birlec heat treatment furnace is specially designed for foundry use. It is of robust construction and has a casing which enables it to be kept clean easily. Birlec Ltd.

Externally, the furnace has been given lines which are in keeping with contemporary machine design, and which enable it to be kept clean with a minimum of difficulty. The door gear is completely enclosed within the furnace casing, the door being operated by an external hand-wheel on the right-hand side. The counter-weight mechanism extends over the roof of the furnace and the weights are located in a compartment at the rear which also houses the transformers for the heating elements. A control panel of similar external appearance to the furnace is provided, and this houses the contactor gear below a temperature indicator. Coloured lights are provided to indicate "power on" and "heat on."

SERVICING FUEL-INJECTION SYSTEMS

A complete range of equipment for servicing Diesel engines of all sizes will be exhibited by the Merlin Engineering Company, Limited, Hebble Mills, Halifax, Yorkshire. In particular, this company is now producing equipment designed to suit the needs of garages that will be faced with the problem of servicing the relatively small Diesel engines being used in private cars, taxis and delivery vans. This equipment includes the Calimaster M6 (illustrated in Fig. 7, opposite), an element comparator and a vice designed for holding the injection pumps for the convenient extraction of the elements.

The Calimaster is designed for calibrating and testing fuel-injection pumps in the categories A, A/A, B and N, and delivering to as many as six cylinders. It is a power-operated test bench of L-form, the upright back housing the injectors, the gravity-feed fuel tank (which is replenished from a reservoir in the base) calibrated test tubes, the counting and trip mechanism, the pump-driving spindle and the tachometer. The base is a box structure for a 2-h.p. motor, a variable-speed transmission and two tanks—one for clean oil, the other for the drainings from the work table. The working speed ranges from 100 to 3,500 r.p.m. and is shown on the tachometer which is calibrated in increments of 25 r.p.m.

On the nose of the driving spindle there is a standard C.A.V.-coupling dog, but adaptors are available for conversion to suit other makes of pump. A 360-degree protractor is fitted to assist in pump phasing. To test the discharge from each of the nozzles (up to six in number) six pintle injectors, set to 175 atmospheres, are mounted in the head of the machine. The injectors are discharged into de-atomising chambers and the oil then drops into the calibrated test tubes mounted in duplicate sets against a rotatable white panel. The number of shots for the test run is pre-set at 100 injections

Fig. 7 The Calimaster M6 is designed for calibrating and testing the fuel-injection pumps for Diesel engines of up to six cylinders. The Merlin Engineering Co. Ltd.

or multiples thereof as required, or the trip gear may be locked in the " on " position for governor observation.

The Calimaster can also be used for testing the auxiliary lift pump from an engine. The pump is connected directly to the main fuel reservoir in the base of the machine, so enabling the pump delivery to be measured against a lift of 3 ft. The normal connection from the lift pump to the injector pumps is broken and re-made, through a pressure gauge, to a calibrated collecting vessel. The fuel pump is then run at a number of engine speeds and the delivery of the pump checked against known requirements.

The body of the machine is of cast aluminium and large access covers have been provided near all the interior equipment. Overall dimensions of the machine are: height, 5 ft. 10 in.; length, 3 ft. 6 in.; width, 1 ft. 8 in. The weight of the machine is about 6 cwt.

TURBINE CONSTRUCTION

Visitors to the stand of C. A. Parsons and Company, Limited, Heaton Works, Newcastle upon-Tyne, will be interested in the lower half of a bladed high-pressure cylinder for a 60-MW 3,000-r.p.m. three-cylinder turbine. Such machines are now among the standard units of the Central Electricity Authority, the steam conditions being 900 lb. per square inch and 900 deg. F. As will be seen from Fig. 8, the blading is arranged on a constant mean diameter so that the cylinder can be constructed with a straight and parallel flange. There are no vertical bolts on the horizontal joint. The two halves of the cylinder are held together by clamps that are applied or taken off by moving them in the horizontal direction. The flanges are very narrow and deep, the upper face of the top flange and the lower face of the bottom flange being machined at a slope of 1 in 8 to the horizontal. The jaws of the clamps are machined to correspond and the clamps themselves are slipped over the flanges and the horizontal studs in the two halves of the cylinder.

The auxiliary shaft for a 60-MW steam turbine will also be shown. This is driven from the high-pressure shaft by a worm and worm wheel, the wheels for the power oil and lubrication being mounted at one end with the speed control governor at the other. Connected to the governor is the plunger which controls the pilot oil pressure to the governor valves by uncovering ports in the regulating bush in accordance with the speed of the turbine, and thus adjusts the opening of the governor valves.

DISTRIBUTION TRANSFORMERS

The range of smaller transformers manufactured by this firm will be exemplified by showing the core and windings of a 1,000-kVA 20,000/433-volt three-phase unit of the indoor type. This core, which is illustrated in Fig. 9, has interleaved yokes and is made up of low-loss electrical steel laminations, each of which is coated with insulating varnish on both sides. The windings are arranged concentrically round the core with the voltage coils on the inside. These windings are of the helical type and are in two layers. The high-voltage windings are of the multi-layer section type. Paper-insulated conductors are used exclusively.

Tappings of $\pm 2\frac{1}{2}$ and ± 5 per cent. of 20 kV are symmetrically disposed about the centre of the high-voltage windings and are brought out to off-circuit tapping switches. The high and low voltage bushings and off-circuit switches are mounted on the transformer cover, which is supported from the top frame bars.

Another exhibit on the stand will be a model of a 120-MVA, 275/132-kV auto-transformer for the Central Electricity Authority. This includes a lower voltage tertiary winding, and the common neutral point will be earthed. On-load tapping equipment is provided on the main 132-kV common winding, the range being ± 15 per cent. in 18 steps. The 275-kV bushings are of the re-entrant condenser type so that a connection can be conveniently made to the top of the winding. For cooling purposes there are four radiators, with auxiliary equipment, controlled by winding temperature indicators which produce forced oil and air circulation.

MULTI-MOTOR CONTROL BOARD

The British Thomson-Houston Company, Limited, Rugby, will be exhibiting a range of electrical and mechanical plant and equipment for marine and industrial purposes. This will include a model of a 5,500-h.p. gas turbine for the Shell tanker " Auris ", which is to replace a turbo-alternator set and the three Diesel-driven alternators now installed.

The multi-motor control board is one of several which have been ordered by Vickers Armstrongs (Shipbuilders), Limited, for a ship under construction. Eighteen others have been ordered for the nine 18,000-ton Shell tankers now being built in British yards. It is designed to control 440-volt, three-phase, 60-cycle motors with a total output of 400 h.p. It is of damp and dust-proof construction and enables the low-tension gear of a number of associated motors to be grouped together. It consists basically of a horizontal busbar chamber which runs the whole length

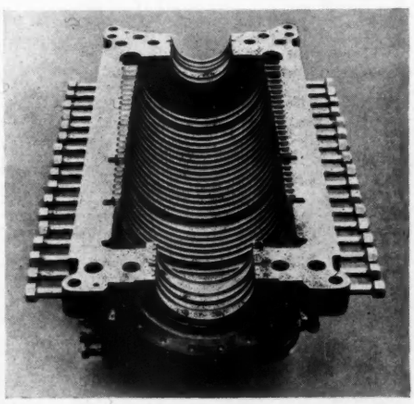


Fig. 8 Bottom half of high-pressure cylinder of 60-MW steam turbine showing arrangement of clamp bolts. C. A. Parsons & Co., Ltd.

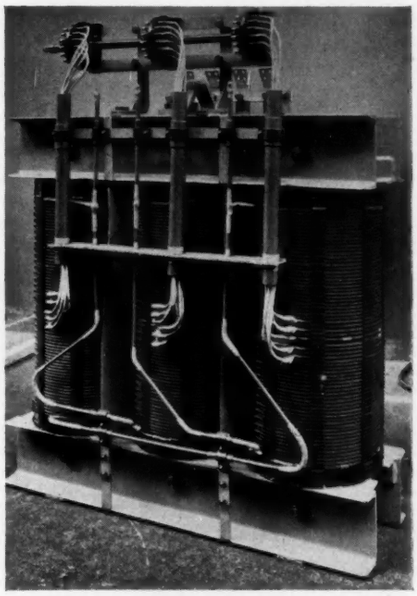


Fig. 9 Core and winding of 1,000-kVA distribution transformer. C. A. Parsons & Co., Ltd.

of the board, with the contactor starters above and below. Isolators and switchgear can be built into or aligned alongside the board to control incoming or outgoing feeders. The starters themselves are of the withdrawable plug-in type, thus facilitating maintenance *in situ* or rapid replacement. The gear is fully protected to a maximum of 25 MVA fault capacity. Five sizes of contactors—of 20, 40, 75, 150 and 300 ampere rating are available. They are of unit construction, all except the smallest size being operated by a single-coil direct-current magnet. Each fixed pole is carried on an arc-resisting moulding mounted on a steel shaft. The moving contacts are located on an insulated shaft and are pivoted on a knife-edge bearing.

Equipment for tankers under construction, which will also be shown, includes the Magnestat (magnetic amplifier) voltage regulator illustrated in Fig. 10. The display will show the voltage dip and recovery time as the load changes on a typical auxiliary alternator. The main components of these regulators are saturable reactors and rectifier elements. They are particularly suitable for marine work as the regulating circuits are entirely static in operation.

WELDING CONTROL EQUIPMENT

The electronic welding control equipment to be exhibited has been designed for use with resistance spot and seam-welding machines, and will provide accurate control of the spot-welding time in one-cycle steps from one to 90 cycles. For seam welding both the heat time and the cool time can be adjusted in one cycle steps from one to nine cycles. Spot welds of one-half cycle duration can also be made. The welding current is variable over a wide range by a heat-control rheostat.

The equipment is intended for operation on a single-phase 50-cycle supply at any voltage between 340 and 500 volts, but to safeguard the operator from shock, the weld-initiating circuit is supplied at 24 volts. The timing unit can easily be removed from the cubicle for servicing or replacement, and the equipment can be made suitable for either spot or seam welding by turning a single switch. Accuracy of timing is ensured by the use of Dekatron cycle-counting tubes and visible indication is given of the weld duration. The current is completely cut-off during the cool time, so that waste heat and distortion are minimised. Synchronous control eliminates current switching transients, and maintenance of the equipment is facilitated by

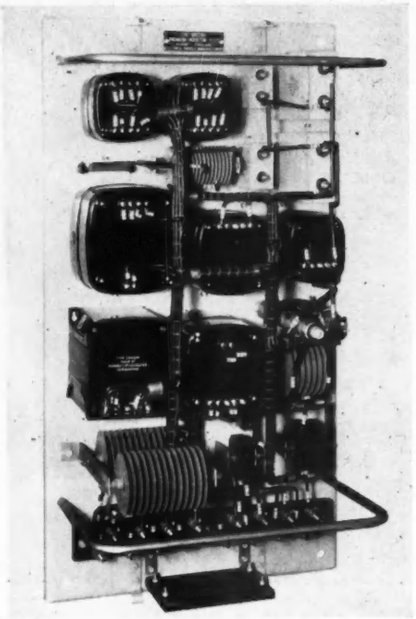


Fig. 10 "Magnestat" voltage regulator (with cover removed) used to control an 8·5-MVA synchronous condenser. British Thomson-Houston Co., Ltd.

the absence of moving parts and contacts in the power circuit.

REMOTE-CONTROLLED SHIP'S TELEGRAPH

Messrs. Chadburns (Liverpool), Limited, Aintree, Liverpool, 10, will be demonstrating their Synchrostep remote-control system by means of which the main Diesel engines or the controllable pitch propellers in tugs, ferry boats and trawlers can be operated from the bridge. The equipment actually to be shown is similar in principle to that installed on two tugs which have been built for the Geelong Harbour Trust by Messrs. W. J. Yarwood and Sons, Limited, Northwich, and are equipped with two-stroke British Polar Diesel engines with an output of 1,310 brake horse-power at 300 r.p.m.

The transmitters, which consist of two single-dial instruments in the wheelhouse and one on the bridge, are mechanically interconnected. They are of the non-reply type, the propeller shaft revolutions and ship's direction being shown on the main and flying bridges by Record electrical direction and revolution indicators. The system is operated by direct current at 110 volts from the ship's generators, but should this fail an alarm is given, both in the engine room and the wheel house, and a stand-by battery is automatically brought into circuit.

When the system is being operated from the bridge a clutch is engaged and lamps showing the condition of the apparatus are illuminated. A movement of the order lever of any transmitter will then actuate the remote-control unit so that the engine throttle is placed in the "ahead" or "astern" position and the appropriate gearing engaged. Further movement of the lever in the same direction will open the throttle to the desired amount.

If the transmitter lever is moved from, say, full throttle ahead to half throttle astern, the remote-control unit will close the throttle and then, after an interval of three seconds, change the gearing from ahead to astern and finally re-open the throttle to the desired position. Moving the lever to the neutral position will close the throttle, disengage the gears and place them in neutral. The gears cannot be engaged or disengaged unless the throttle is closed, nor can the throttle be opened while engagement or disengagement is taking place. On moving the bridge transmitter to the desired amount of throttle, the order pointer in the engine room moves to the corresponding position. At the same time the bell in the engine room and a buzzer on the bridge will operate for five seconds.

When the clutch mentioned above is disengaged the engines can be controlled locally in the engine room instead of from the bridge, red warning lights being incorporated in the bridge transmitters to indicate this condition.

350-kW GAS TURBINE

The exhibits on the stand of W. H. Allen Sons and Company, Limited, Bedford, will be arranged to represent some of the firms specialised activities in the design and construction of generating plant, pumping machinery and electrical equipment.

Among them mention may be made of the 350-kW gas turbine, illustrated in Fig. 11. This is a larger version of a set already described in ENGINEERING* and is one of eight which are to be installed on ships of the Blue Funnel line. In this set air is drawn into a compressor with a compression ratio of 2·7 to 1 and is then diffused into an annular air casing, which completely surrounds the turbine casing. The air next passes into a casing surrounding the combustion chamber flame tube. Some air also enters this flame tube at the top through a swirler, where it is mixed with the fuel atomised by the burner. The products of combustion are cooled to the designed working temperature by the excess air which enters the flame tube through dilution holes. The gases are then discharged through the stator and turbine blading where the heat energy is converted into mechanical energy.

The compressor is of the two-stage axial-flow type, the rotor blades being of aerofoil section and being machined integral with the roots from Nimonic 90 bar. They are fitted in axial fir-tree slots in the periphery of the rotor wheels and secured axially by a locking ring. The combustion chamber, which is of the single reverse-flow type was designed by J. Lucas (Gas Turbine Equipment), Limited. It is mounted vertically above the shaft and is fitted with a Lucas fuel-oil burner. The flame tube is made of Nimonic 75.

The fuel and air mixture is ignited for starting purposes by a high-energy surface-discharge unit which incorporates a torch ignitor operated from a 24-volt direct-current supply. The starting equipment is of the Rotax multi-breech turbo-type, which is powered by cordite cartridges. The speed governor is of the centrifugal pattern and is driven through bevel gearing from the slow-speed shaft of the reduction gear. Four separate pumps are provided for lubrication purposes, while the fuel oil system consists of a "spill" burner which is supplied from a pump of the swash-plate type. Heaters are incorporated in the system to pre-heat the fuel; and an automatic device prevents over-fuelling which would result in an excessive turbine inlet temperature.

The speed reduction gear is of the Allen-Stoeckicht double-helical, planetary single-reduction type and reduces the speed of the turbine from 15,000 to 1,500 r.p.m. The 350-kW direct-current generator, which runs at the latter speed, is designed to work in parallel with two 450-kW Diesel sets, which are also to be installed on the ships.

* Vol. 177 page 637 (1954).

ELECTRICALLY-DRIVEN SEWAGE PUMPS

Fig. 12 shows a model of a vertical motor-driven pump which will be exhibited on the same stand, and is one of six which are being supplied to the London County Council for emergency duty on the sewage system. These pumps are designed for an output of 13,000 gallons per minute against a head of 35 ft. and are directly driven by 200 brake horse-power three-phase slip-ring induction motors running at 730 r.p.m.

Each pump is of the Allen-Stork mixed flow type and, as will be seen from the illustration, the motor is mounted on a pedestal above it, thus giving a compactness of arrangement and ample space for inspection. The arrangement also enables the pump to be dismantled, after removing the motor, by lifting the pedestal and top cover. At the same time the shaft and impeller can be taken away complete leaving the casing in position, and enabling the unit to be opened for inspection without breaking the pipe joints.

AUTOMATIC STEERING GEAR

Several types of steering gear will be shown by S. G. Brown, Limited, Shakespeare-street, Watford, Hertfordshire in addition to other items of marine and telephonic equipment.

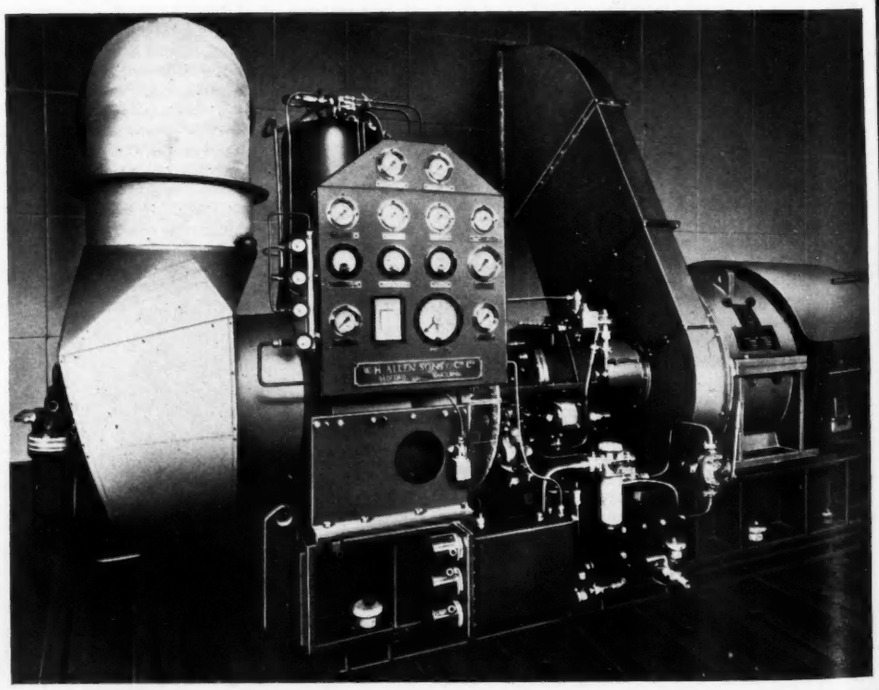


Fig. 11 350-kW gas-turbine-driven direct-current generator for marine stand-by and emergency duty. W. H. Allen Sons & Co., Ltd.

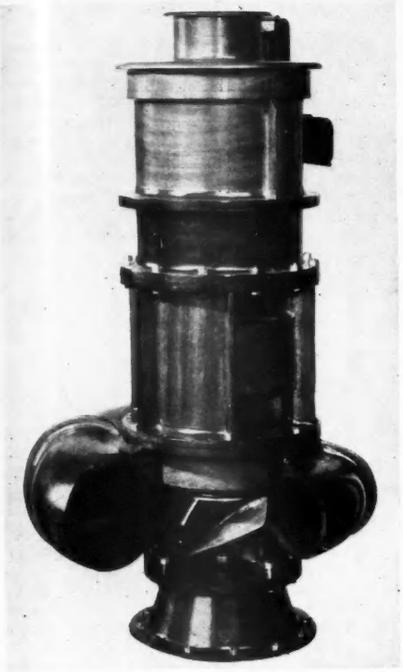


Fig. 12 Scale model of vertical motor-driven mixed-flow sewage pump. W. H. Allen Sons & Co., Ltd.

There will be a new self-contained master gyro-compass—the mark IX square binnacle—which embodies switchboard control gear and electronic repeater equipment in a space very little larger than is required by a standard magnetic compass. It is shown in Fig. 13. Other models are fitted with a stream-lined repeater on the top, or, for small vessels, without any repeating equipment.

Intended to work with a gyro-compass is a recently-designed automatic steering-gear, which also conforms to space-saving requirements. Known as the type E mark II, it is for use with any hydraulic steering gear with telemotor bridge control. The cabinet outline is square, similar to that of the binnacle compass, and a new feature is a combined "helm-applied" and "angle-on" indicator. This has two independent pointers on a radial scale, one of which denotes the helm angle applied and the other repeats back the actual rudder position. On switching to manual steering, both the pointers, and the rudder, automatically return to the midships position. All models also incorporate a three-position control lever providing for "automatic," "hand-electric" and "off."

Again with the aim of saving space, a new combined steering console will be shown, which has been developed in collaboration with John Hastie and Company, Limited, 10 Princes-street, Greenock, Renfrewshire. In it are combined the telemotor gear and the automatic equipment giving a considerable saving of space over two separate units. The two systems are independent, and changeover controls are fitted on the console. Concentric wheels allow of either hand-hydraulic or hand-electric steering and a mechanical indicator is geared to the normal handwheel as in general practice. A standard multiple-bearing repeater is mounted above the console.

A redesigned version of Brown's rudder angle indicator will also be shown, using a new transmitting element to reduce cost. It has a dead-beat action and the pointer does not suffer from waver or wobble. A heading indicator which has a magnified scale and is intended for fitting at the fore-end of the bridge or in the radar room will also be exhibited.

DEPTH RECORDER

Also to be shown on the stand of S. G. Brown, Limited, is a depth recorder for shallow waters which is made by the Submarine Signal Company (London) Limited. It is similar in form to other "Subsig" recorders but is designed to cover depths up to 360 ft. in two stages. It can be fitted as a "keel" mounting on wooden hulls or as a "pierced" mounting for steel vessels. The dry Teledeltos type of paper is used, which does not shrink or fade, and provides a permanent record. Models are available for 12, 24 or 110 volts direct current, or 115/230 volts alternating current. The associated converter unit is fully suppressed.

HIGH TENSION SWITCHGEAR

Fig. 14 is an illustration of the 250-MVA, 11-kV circuit-breaker unit which will be exhibited by George Ellison, Limited, Perry Barr, Birmingham, 22. It has been tested by the Association of Switchgear Testing Authorities and complies with British Standard No. 116.

The circuit-breaker is vertically isolated, and is supported on a wheeled truck so that it can be easily withdrawn for inspection. The arc control devices are of the cross-blast type and can also easily be removed for contact examination. Arrangements can be made for single or duplicate busbars, with or without selector switches, and operation can be effected either manually, or by spring power, or by direct-current solenoid. Safety interlocks are incorporated.

A 45-MVA 660-volt switchboard, which will be shown by the same firm, is also designed in accordance with the standard quoted above, and consists of two circuit-breaker units. It is so arranged that further units can be added as required. The breakers are isolated from the busbars by horizontal withdrawal, and interlocks ensure that they are "off" before isolation takes place. They are supplied with current ratings up to 2,400 amperes.

The stand will also contain a display of motor starters among which will be an oil-break circuit breaker for direct-to-line starting and feeder circuits operating at voltages up to 660 volts. This contains a built-in isolating switch with high-rupturing-capacity fuses and auxiliary switches. A group of these breakers will be

Fig. 13 Self-contained gyro-compass binnacle. S. G. Brown, Ltd.

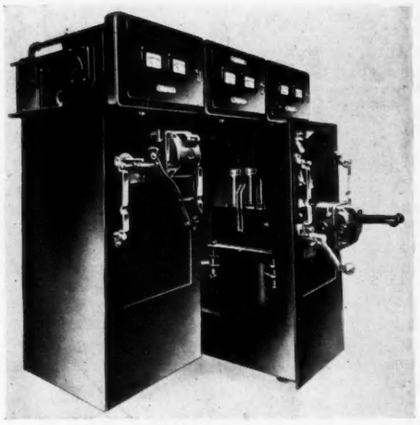


Fig. 14 250 MVA, 11 kV switchboard with one circuit breaker lowered for isolation, and the truck withdrawn. George Ellison, Ltd.

shown mounted on a busbar chamber for the sequence starting of electric motors.

In addition to this and other switchgear a number of hydraulic valves for hand and pneumatic operation will be shown. These are of the screw-down pattern and are designed so that when they are closing foreign matter can pass between the seating faces. Interlocks are incorporated to prevent water wastage.

PRESSURE VESSELS AND OTHER METAL WORK

The difficulty of many of the firms showing at this exhibition is that their main output consists of special jobs made to order, and examples are neither available nor convenient for display on a stand. Such a firm is G. A. Harvey and Company, Limited, Greenwich Metal Works, London, S.E.7, fabricators of specially designed plant in welded stainless steel, Monel and nickel as well as mild steel. This work—for which recent extensions have been added to the shops at Greenwich—ranges from small autoclaves for working pressures of 3,000 lb. per square inch up to fractionating columns weighing as much as 220 tons and gas/oil separators made from 3-in. thick mild steel and 4 ft. 6 in. in diameter by 170 ft. long. Besides this work of making pressure vessels of all sizes, more general production is undertaken with plate from $\frac{1}{4}$ in. to 6 in. thick for turbine casings, heavy fabricated press members, engine frames and cement-drying kilns. All this work has necessarily to be portrayed at the exhibition only by a display of photographs.

The sale of components for the fabrication of pressure vessels, however, has been the business of the company for many years and they are able to supply a full range of Harvey "Rotarprest" heads, dished and flanged ends, channel, angle and flat bar rings. Examples of hardware on the stand will include a wide range of filled tubes, and "Harco" perforated metal and plastics items for sifting, filtering and grading such diverse materials as coal, stone, cereals and other food products, fine chemicals, etc. The radiator covers, pipeguards and ventilating grilles will be of particular interest to the designers of ships' furnishings and equipment.

Sheet metal-work is another trade in which Harveys have specialised since the company was first established, and the display will include examples of mild-steel rainwater goods, ventilators and chimney cowls. A range of "Harvey" steel office and factory furniture for filing and storekeeping will also be found on this stand.

FANS

In addition to a range of fans for many purposes, Keith Blackman, Limited, Mill Mead-road, London, N.17, are to show their new Keno washer for removing fine dust particles from air streams. Briefly, a rotating helix lifts water

from a storage tank and discharges it radially at high velocity. The water forces its way through a squirrel cage over which the contaminated air is drawn by a fan. Drain water from the top section provides a curtain of water over the inlet. A scraper bottom can be provided if desired, or alternatively a continuous sludge filter can be fitted.

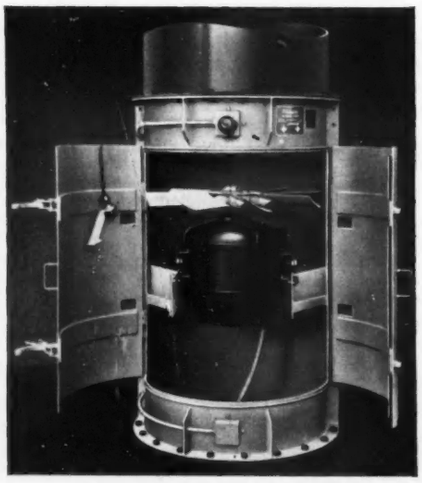
Among the fans is the one shown in Fig. 15, a 33-in. diameter reversible unit for engine room and cargo space ventilation. It is one of a range with impellers varying from 16 to 48 in. in diameter. When it is required to reverse the flow of air, fan and motor are simply turned through 180 deg. on the pivot mounting. The illustration also shows the accessibility of the fan for maintenance. This particular size has a rating of 15,000 cub. ft. per minute when running at 1,340 r.p.m. under a pressure of 1·64 in. water gauge.

Other fans exhibited for the first time will be two series which are made of rigid P.V.C. Series I are moulded and are direct driven by Keith Blackman motors, and Series II are fabricated and have a pulley for an indirect drive. Three sizes of the first series are made, numbers 6, 12 and 18, those being the diameters of the impellers. The second series ranges from 15 in. to 42 in. in diameter. It is claimed that the two series together offer the widest range of plastic fan sizes and duties available in this country. Overall, the range covers 50 cub. ft. per minute up to 40,000, at pressures of 4 in. water gauge. The example to be shown of the Series I fans will be the middle size, and this will be supplemented by a half casing and impeller to show the smooth internal surfaces. The impeller is of the backward curved, open paddle blade type. These P.V.C. fans are resistant up to 120 deg. F. to fumes from such chemicals as acetic acid, ammonia, photographic developer, hydrochloric acid, etc.

CARBON-LINED PIPES

The increase in production and use of corrosive liquids has intensified the problem of conveying them in a pipeline. In many respects carbon is the most suitable material for the pipe because of its resistance to most chemicals, even in the hot state. But it is comparatively fragile in the form of tubes and, of itself, can be used only for low pressures and for short pipelines.

The weakness has been eliminated by the Talbot Stead Tube Company, Limited, Greenlane, Walsall (a member of the T.I. group of companies), who have introduced "Metica," which is, in fact, a double tube: an inner tube of carbon or graphite protected by an outer tube of steel. Samples of the tubing, together with fittings that ensure continuity of the carbon within the pipe, are to be exhibited for the first time at Olympia.



[Fig. 15 33-in. reversible fan for ventilating systems. Keith Blackman Ltd.

Two grades of lining are available. For applications where a high thermal conductivity is required, impervious graphite is recommended; it has a thermal conductivity in excess of 60 B.Th.U. per hour per square foot per degree F. per foot. Where strength combined with high resistance to corrosion is necessary, an impervious-carbon lining is available; it has a minimum ultimate strength of 5,000 lb. per square inch in bending, 15,000 lb. per square inch in compression and 3,000 lb. and 3,500 lb. per square inch in tension and shear, respectively. These two linings are covered by an external metal sheath which might be of mild or high carbon steel, alloy (including stainless) steel, or alternatively, brass, copper, etc.

Resistant to both hot acids and alkalis, including the corrosive solvents used in the oil industry, Metica is available with the following (nominal) bores: $\frac{3}{8}$, 1, $1\frac{1}{2}$, 2, 3 and 4 in.

PORTABLE THREAD CUTTING MACHINE

Among the many exhibits which will be demonstrated on the stand of Wright Electric Motors (Halifax), Limited, Pellon-lane, Halifax, mention may be made of the tangential self-opening thread cutting machine illustrated in Fig. 16. This has been designed for use on production lines and embodies a die head which opens automatically at the end of a pre-set length of thread. Fine adjustment of the diameter is possible by screw and micrometer scale. The chaser dies are of high-quality tool steel and are secured by a quick-acting locking device. The vice is of self-centring quick-acting precision type and is fitted with a quick-acting hand lever. The work is continually lubricated and cooled by a pump in the two speed gearbox, the oil being discharged by a flexible pipe to the die head, and collected in a tray in the base of the machine. A removable swarf strainer is fitted.

The machine is driven by a dust-proof electric motor which is coupled to a completely-sealed two-speed gearbox. This motor may be either of the single or three-phase type and is designed so as to be capable of starting on full load. It is controlled by a push button, an automatic cut-out being fitted to prevent overload. With normal motors two cutting speeds are available. Four speeds can, however, be obtained by using a pole-changing motor. As will be seen, the machine is mounted on a two-wheel trolley and is thus easily moved.

TUBE CUTTER

The tube-cutting machine, which is being exhibited by the same firm and is illustrated in Fig. 17, is also readily movable since it is mounted on a similar stand to the thread cutter. It can be used on tubes from $\frac{1}{2}$ in. to 2 in. in diameter and both cutter and motor can be controlled by a single lever so that operation by unskilled labour is possible. Normally, the length of pipe required is selected by setting a standard gauge, but for close-limit operation on repetition work a micro-gauge scaled to 0·002 in. is available. The machine is driven by a dust-proof motor through gearing immersed in an oil-bath, and the cooling lubricant is circulated by a built-in pump.

The cutting-off operation only occupies a few seconds and either straight cuts or weld chamfers can be produced. Burrs are automatically removed by a reamer which rotates alongside the cutting tool.

DIESEL-ENGINED WELDER

The Quasi-Arc Company, Limited, Bilston, Staffordshire, will be exhibiting the new 400-ampere engine-driven welder illustrated in Fig. 18. This consists of a Ford Diesel engine of the four-cylinder type with a rated output of 34 brake horse-power at a speed of 1,500 r.p.m., and which is fitted with a decompressor to facilitate starting. The radiator is of the Dewandre horizontal removable-tube type. The engine is designed both for hand and electric starting, the starting motor being supplied from a battery which is charged from a separate generator. The engine

Fig. 16 Portable thread-cutting machine. Wright Electric Motors (Halifax), Ltd.

Fig. 17 Tube-parting machine. Wright Electric Motors (Halifax) Ltd.

is mechanically governed and the cooling water temperature is thermostatically controlled. The welding generator is designed to give a maximum output of 400 amperes at 55 to 70 volts. The control unit incorporates a current selector switch and a voltage rheostat giving fine control over the current range from 60 amperes upwards.

As will be seen, the set is mounted on two-wheeled Flexitor undergear, which comprises a cylindrical shaft bonded to a rubber block. This block is, in turn, bonded to and contained in a flanged steel housing. The projecting end of the shaft is serrated and carries a drop arm which is welded to the stub axle carrying the wheel. This type of suspension enables the set to ride smoothly over the roughest ground and, being totally enclosed and without a rubbing surface, is not subject to abrasive wear.

SIGMA PROCESS

The same firm will be demonstrating the Sigma (shielded-inert-gas metal-arc) welding process for the first time at this exhibition. In this method of joining metals the electric arc is shielded by an inert gas, the consumable electrode being a bare wire, and a fully-automatic head

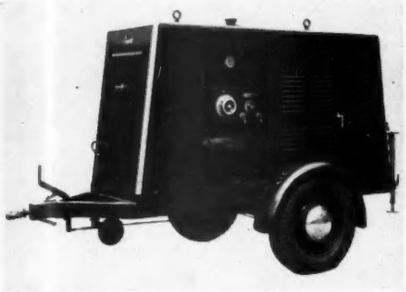


Fig. 18 400-ampere Diesel-engine driven welding set. Quasi-Arc Co., Ltd.

being used. Demonstrations will be given of mild-steel welding by the SWM semi-automatic process, which is also suitable for welding aluminium and its alloys, corrosion and heat-resisting steels, and copper and its alloys.

PROJECTION WELDER

The largest machine on the stand of Sciaky Welding Machines, Limited, Farnham-road, Slough, Buckinghamshire, will be the projection welder illustrated in Fig. 19. This has a nominal rating of 100 kVA, and a welding current of 120,000 amperes can be obtained across the 14 in. by 14 in. T-slotted platens. Even distribution of the current over the platen area is ensured by the use of dual transformers, one of which is mounted on each side of the machine. The heavy box-section bridge-type frame enables the work pieces to be discharged on the opposite side to the loading position. The upper platen is operated pneumatically, air being supplied at a pressure of 10,000 lb. from a cylinder 12 in. in diameter. This is mounted centrally in the frame so that unbalanced stresses are avoided.

The automatic welding cycle, which includes a post-weld forging operation, is initiated by push buttons, and is controlled by two electronic timers. The welding current control incorporates the firm's phase-shift heat unit, which operates in conjunction with an ignitron contactor panel.

Among the spot welders to be shown on the same stand will be two, one of 150 kVA and the other of 25 kVA nominal capacity. Each of these has a throat depth of 24 in., while the smaller model can be used for welding up to two thicknesses of $\frac{1}{8}$ in. mild steel. The larger machine is capable of fabricating light alloy components having two equal thicknesses of No. 14 s.w.g. sheet and mild-steel plate up to $\frac{3}{16}$ in.

Fig. 19 100-kVA projection welder. Sciaky Welding Machines, Ltd.

HIGH FREQUENCY RADIO TELEPHONE

The very high frequency radio telephone which will be exhibited by Redifon, Limited, Carlton House, Lower Regent-street, London, S.W.1, is of interest since it provides facilities for both amplitude and frequency modulation in the same unit. It therefore meets the need of port and harbour services, as well as of tug and fishing fleet owners and pilots, for a rapid and economical means of communication in both directions between ship and shore.

A range of six models employs one or more ten-channel transmitter/receiver units which are supplied with power from either the ship's mains or batteries. Each transmitter/receiver can be set up for operation on any frequency band—not more than 2 megacycles wide—within the 40 to 185 megacycle range. A 20-channel version incorporates two separate and independent frequency bands.

The basic unit, which is illustrated in Fig. 20, consists of a very high-frequency crystal-controlled receiver and transmitter mounted on the same chassis. The power output to the aerial circuit is about 10 watts. At frequencies above 150 megacycles it is not less than 9 watts on frequency modulation or 7·5 watts on amplitude modulation. The receiver sensitivity for a 10-decibel signal to noise ratio is one microvolt when modulated 30 per cent. at 1,000 cycles on amplitude modulation, or 10 kilocycles deviation at 1,000 cycles on frequency modulation. If the frequency deviation exceeds 15 kilocycles a limiter comes into operation. Electronic "squelch" control circuits are provided, the sensitivity of which is from 1 to 3 microvolts with both amplitude and frequency modulation. Miniature two-pin crystals are employed, the frequency tolerance of which is 0·003 per cent. of the correct frequency.

Local control is by a hand set of the moving-coil type with a "press-to-talk" switch, but remote control can be provided by a miniature loud speaker which gives audible warning of incoming calls and permits monitoring on the frequency to which the receiver is tuned. Removing the hand set from its cradle cuts off the loudspeaker, so that normal simplex conversation is possible by pressing a switch.

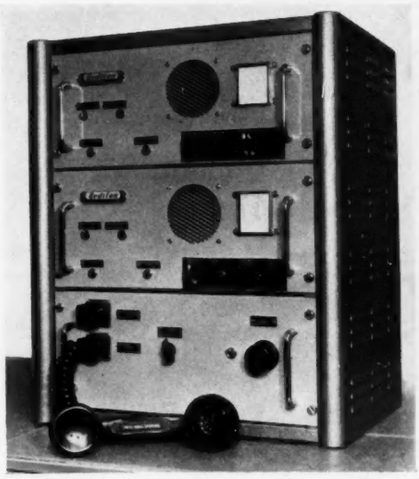


Fig. 20 Combined amplitude and frequency-modulated radio telephone. Redifon, Ltd.

LIGHT-WEIGHT HYDRAULIC PRESSES AND CROPPERS

The hydraulic presses and croppers to be exhibited by Pilot Works, Limited, Manchester-road, Bolton, Lancashire, will include a new light-weight press of 15 tons capacity. They will also show a 12-ton hydraulic press with a stroke of 6 in., and a hydraulic cropper capable of making up to 34 cuts per minute. It will cut flat mild steel bar 2 in. by $\frac{1}{2}$ in., 3 in. by $\frac{3}{8}$ in. or 4 in. by $\frac{1}{4}$ in., and up to $\frac{1}{4}$ in. thick.

The new press, shown in Fig. 21, is of all-welded construction, with main side plates of 1-in. mild steel. An oil tank of six gallons capacity is built into the main frame between the side plates. A two-cylinder plunger-type pump and a gear-type booster pump are located in the oil tank, the pumping gear being fully immersed. The pumps are driven by a 4-h.p. electric motor running at 950 r.p.m. and suitable for alternating current at 380/440 volts, 3 phase, 50 cycles. As an alternative, a motor suitable for 220/250-volt, 3-phase, 50-cycle current can be fitted without extra charge.

The hydraulic cylinder is of the double-acting type, with an outer ram of 4 in. bore and an inner ram $2\frac{1}{2}$ in. outside diameter. Four piston rings are fitted to the inner ram. A 1-in. diameter tool socket $2\frac{1}{4}$ in. deep is provided in this ram, which is linked to a guide bar 2 in. in diameter. The stroke is $8\frac{3}{4}$ in. A detachable bedplate 12 in. by 14 in. is retained in position by four $\frac{3}{4}$-in. Allen socket-head screws, and there is a slot $2\frac{1}{4}$ in. by 7 in. centrally in the bedplate.

Control of the machine is by a hand lever on the right-hand side of the bedplate, connected to a rotary valve built into the main frame. The daylight available is $16\frac{3}{4}$ in., and the throat dimension is $8\frac{1}{2}$ in. On the down stroke the maximum pressure available is 15 tons; this can be varied as required in the range 1 to 15 tons by a hand-wheel control. A pressure gauge built into the head of the machine shows the working pressure. On the up stroke the maximum force available is 5 tons; this is varied in proportion as the down stroke pressure is adjusted. The press has an approach speed of approximately 25 ft. per minute, the complete down stroke taking 1·75 seconds when not under load. Pressing under load is at 25 in. per minute, or 1 in. in 2·4 seconds. The return speed is at approximately 35 ft. per minute, the full stroke being made in 1·25 seconds.

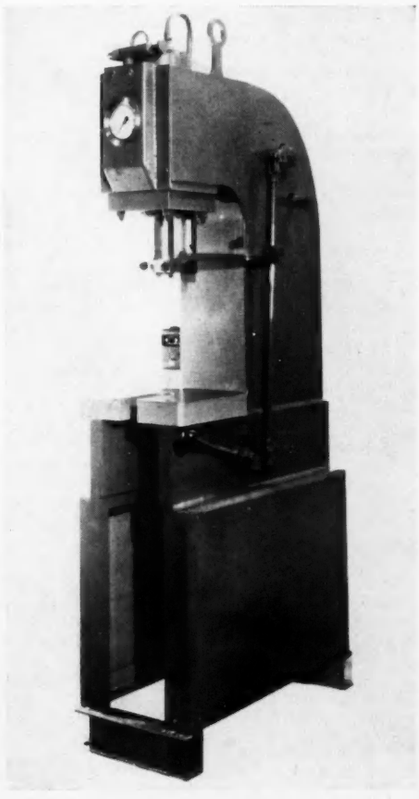


Fig. 21 15-ton hydraulic press with a stroke of $8\frac{3}{4}$ in. Pilot Works, Ltd.

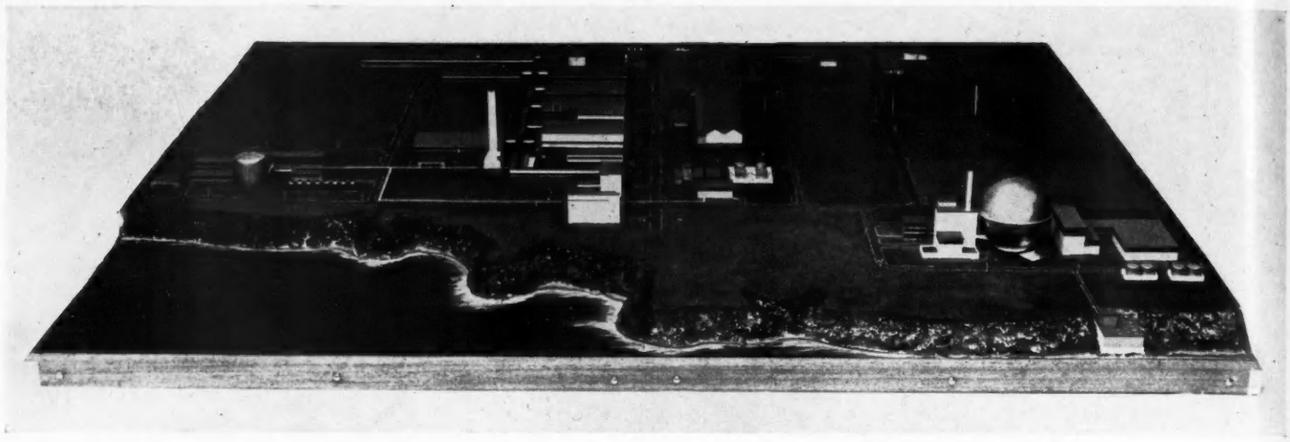


Fig. 1 Model of Dounreay site. The fast reactor (bottom right) makes more efficient use of natural nuclear fuels than a thermal reactor.

THE DOUNREAY FAST REACTOR

At Dounreay, on the north coast of Scotland, the United Kingdom Atomic Energy Authority is building a fast reactor designed to use as a fuel source the non-fissile isotope, uranium 238. *Uranium* 238, *which is considerably more abundant in nature than uranium* 235, *can be converted into a fissile material, plutonium, by fast-neutron bombardment, thus providing a nuclear fuel. The Dounreay experimental reactor is intended to make the best possible use of natural uranium containing both isotopes and will, therefore, be the forerunner of more economical installations than those based on the more familiar thermal reactor. A description of the Dounreay project was given in a paper presented by Mr. J. W. Kendall and Mr. T. M. Fry, of the U.K.A.E.A., at the International Conference on the Peaceful Uses of Atomic Energy at Geneva on Saturday, August* 13, *and an abridged version of the paper follows.*

FAST AND THERMAL REACTIONS

The fundamental reason for developing the fast reactor for the generation of industrial power was that it seemed capable of much more efficient utilisation of uranium fuel than a system based on thermal fission. Natural uranium consists of a large percentage of uranium 238 and a small percentage of uranium 235. The energy content of uranium 238 is little different from that of uranium 235, but when natural uranium is fed into a thermal system, all but a few per cent.—depleted in its content of uranium 235—must be discarded as waste. The need to conserve uranium may not be great at present but ultimately the possibility, afforded by the fast system, of using almost all of the uranium, should be most attractive.

A fast-neutron chain reaction cannot be sustained in uranium of natural enrichment. The core of the reactor must be charged with a much higher proportion of fissile material, either uranium 235 or plutonium 239, than is present in natural uranium. The cost of fissile material is measured in thousands of pounds per kilogram so that the initial charge represents a substantial capital investment. If it is to be used as a " catalyst " for deriving power from uranium 238, each kilogram of fissile material must yield hundreds of kilowatts of electricity. This sets one objective for development; we cannot consider the fast reactor as an economic source of power until ratings of this order have been demonstrated. Moreover, this rating must be based on the total fissile investment in the whole system, including processing plants, and not just that in the reactor.

HIGH OUTLET TEMPERATURE

The second target for development is outlet temperature. The heat produced in a power reactor must be at a sufficiently high temperature to be converted into power with useful efficiency.

Ideally, natural uranium would be fed into the reactor and the fission products removed continuously. In practice it will be necessary to remove the fuel periodically for purification and re-fabrication, an expensive process which also increases the investment of fissile material needed to operate the system. This sets the third criterion of successful operation of a fast reactor; the cost of processing the fuel must not be excessive. If the process is expensive or takes a long time, the fuel must produce a lot of heat before processing is necessary. It is difficult to give an exact figure, but, with the processes at present envisaged, a burn-up of the order of 10 per cent. of the fissile material is probably needed. At the ratings required, this would take a few months irradiation in the reactor.

Finally, if the reactor is to be sited in the United Kingdom, it must be safe.

FLEXIBLE DESIGN

At Dounreay, on the north coast of Scotland, the United Kingdom Atomic Energy Authority is building a fast reactor, a model of which is shown in Fig. 1. The project is essentially experimental, for no engineering experience is available on which to design a core with the rating, outlet temperature and burn-up required. The best way to obtain this knowledge seems to be to build a plant having the most flexible design that can be achieved. As failures are replaced by better components it is hoped to demonstrate that a fast reactor can be a sound economic proposition for the production of industrial power.

At this point mention must be made of the achievement in the United States of the production of electrical power from a fast reactor, the EBR, as long ago as December, 1951. While this has shown that many of the technical problems can be overcome, a much bigger output must be attained if the power is to be produced at an economical cost. While not going the whole way to that suitable for a full-scale generating station, a core size has been selected for the Dounreay reactor, about 2 ft. in diameter and 2 ft. long, from which it should be possible to extrapolate to a larger reactor.

The plant will consist of a pot through which enough coolant can be pumped to remove more than 60 MW of heat. In this pot, tube plates and other structures can be placed to support the blanket and core of the reactor. If experience shows that the first designs are unsatisfactory, the contents of the pot can be removed and a fresh start made. Fig. 2 shows the arrangement of the reactor.

LIQUID-SODIUM COOLANT

If high heat output is to be obtained, a coolant of high specific heat and high thermal conductivity is needed because of the small core size, while a low vapour pressure is a great advantage. These considerations led to the choice of liquid sodium with possibly some addition of potassium to lower the freezing point. Small-scale experimental knowledge of these coolants was available when this choice was made. A diagrammatic layout of the liquid-metal and steam circuits appears in Fig. 3.

The reactor will cost some millions of pounds, and its core will contain a substantial quantity of fissile material. It therefore represents an investment which must not be lost as the result of an accident. Because of the persistence of heat release after reactor shut-down, it is essential that a supply of coolant to the core shall be guaranteed at all times. The core of the fast reactor is so highly rated that it would quickly rise to melting point if the coolant were removed.

The circuit will be made from stainless steel throughout. This is a good material for high working temperatures and also helps in providing a clean oxide-free circuit. Twenty-four parallel loops, each comprising two separate heat-exchanger sections and an electro-magnetic pump, will complete the primary circuit. The lower part of each loop will be jacketted with an outer tube through which the secondary coolant will be pumped. Above this will be a short flattened section against which are pressed the electro-magnetic windings. At the top will be another jacketted heat-exchange section, providing thermo-syphonic rejection of shut-down heat to air, in the event of total failure of electrical supplies. Twenty of the loops feed the core from a common header-space at the top of the pot, while four more provide coolant for the blanket.

Adhering to the principle that the removal of heat must be maintained, multiple secondary and subsequent heat-rejection circuits will be provided. Even the power supplies will be separated. Electrical power for the pumps will be provided by Diesel generators, each of which will be connected to only two of the primary pumps and their subsidiary circuits. Thus the failure of one generator will only cut out one-tenth of the pumps. The flow through the core will fall by a rather larger fraction because some coolant will flow in the wrong direction through the ineffective pumps. Even so, the reduction in flow will not be by a dangerously large amount.

NON-RADIOACTIVE SECONDARY COOLANT

Sodium or sodium-potassium alloy will be used for the secondary coolant. On grounds of safety it is argued that the secondary coolant must be chemically inert to the primary coolant; this rules out water. The secondary coolant will carry the heat to a boiler-house for steam raising. As there will be no radioactivity involved, a reaction between sodium and water in this part of the plant would not involve widespread hazard. Waste heat will be disposed of by a sea-water cooled condenser.

The secondary coolant must not become radioactive, so a neutron shield is needed between the pot and the heat exchangers. This shield can also perform another function. Measurements of fission rate must be obtained even when the reactor is shut down, and in fact, it is especially important to make measurements when the reactor is not generating appreciable quantities of heat, for it is then that reactor accidents are likely to happen. A detector of thermal neutrons, placed in a mass of moderating material outside the pot, should be employed combining sensitivity with accessibility. The neutron shield consists of graphite stacked round the pot to a thickness of 4 ft., and most of the graphite will contain enough boron to absorb neutrons when they have slowed down. In a belt at the level of the core, pure graphite will be used for all but the outermost layer. In this region a high density of thermal neutrons will build up, making it possible to determine the fission rate down to very low levels. To ensure that this rate can never fall below the minimum observable, a neutron source will be placed in the reactor.

The advantage, which it is hoped will be gained by the use of borated graphite for absorbing neutrons, is that very much less long-lived activity will be induced than if steel were used. This should simplify the problems of dismantling the neutron shield should it ever be necessary. The graphite will be kept hot to reduce radiation damage.

CONTAINING SPHERE

The graphite and the pot will be supported on a steel structure standing on a concrete base, which forms part of the biological shielding. This will consist of a concrete bowl almost 90 ft. in outside diameter, and 45 ft. high, with minimum thickness 5 ft. These dimensions are determined by the size of the heat exchangers and the activation of the coolant. The roof slab, which has a central hole 20 ft. in diameter, will be supported on a ring of vertical columns. These introduce complications because they will stand in the space to be occupied by heat-exchange equipment, but the slab is too large to be supported round its rim without introducing a prohibitive concentration of reinforcement near the centre. The heat exchangers will hang from the roof slab.

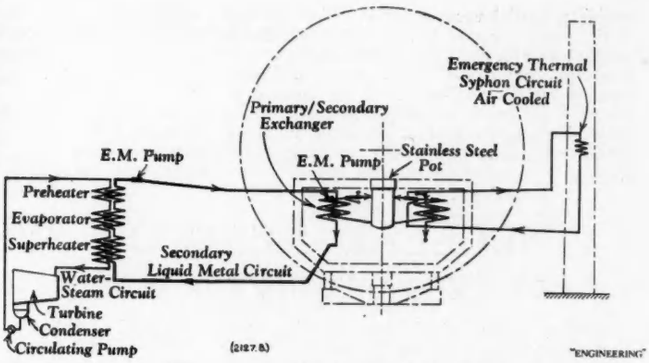


Fig. 3 To obtain good heat-transfer, liquid sodium with possibly some potassium addition is used as coolant. The secondary circuit, which carries heat to the boiler house for steam raising, also contains liquid sodium, which will be non-radioactive; thus there can be no contact between water and radioactive sodium.

Pure sodium is a better heat transfer medium than the alloy and is much cheaper, but, if it is to be used, the entire primary circuit must be kept above the freezing point of sodium so that blockages cannot occur. The whole of the vault will therefore be made into a hot-box, with air heaters. The concrete and the columns supporting the roof will be lagged and air cooled. In the early stages of operating, sodium-potassium alloy will be used so that the vault will be accessible when the activity of the coolant has died away after shut-down.

This is a reactor which may require alteration and development before its operation is entirely satisfactory. For this reason there is to be a large hole in the roof slab, closed with removable shielding, and it should be possible to remove the equipment from the vault through this hole. In the centre, the top of the pot will be closed by a thick plug of shielding in the form of eccentric cylinders with liquid lute seals, which can be rotated to align the charge machine over the inside of the pot. During operation the plug will be sealed mechanically against the coolant pressure with an intervening gas blanket.

Following the example of the Knolls Atomic Power Laboratory at West Milton, the Dounreay reactor will be enclosed in a steel sphere 135 ft. in diameter and about 1 in. thick.

EXPLOSION PRECAUTIONS

A theoretical examination of the problem of the safety of fast reactors has been made, and the magnitude of the explosion that would occur, if the reactivity were rapidly increased beyond prompt critical, has been estimated. It is doubtful whether a pressure vessel of practicable dimensions could contain such an explosion. It is confidently believed, however, that the danger can be eliminated by suitable design of the control system and of the core itself.

Although an explosion will not occur, one cannot be quite sure that there will be no sort of plant failure which could result in fission products escaping. With something like a hundred million curies in the core, an escape of more than a few per cent. would be a very substantial hazard over a wide area. The sphere has therefore been designed to contain these fission products in the very improbable event of their escape from the core.

The liquid-metal coolant brings with it a risk of fire. To reduce this risk no significant quantity of water will be allowed inside the sphere, but there will be about 13 tons of oxygen in the air. The vessel is not designed to contain the pressure that would develop if all this oxygen were to combine instantaneously with sodium. This, however, is unlikely to occur.

Sodium is a poor fuel. Like other fuels it reacts with air in the vapour phase. Its high boiling point, 883 deg. C. and high latent heat of vaporisation (1 kilocalorie per gm.) make it slow to burn in air. The heat of combustion is only 2 kilocalories per gm. so that half of this must be fed back to vaporise a further supply of fuel for the fire. The high thermal conductivity tends to conduct heat away from the burning surface, which is quickly covered with an insulating layer of oxide. A sodium fire will therefore not be self-sustaining at a high rate of combustion. The heat necessary for vaporisation must be derived from some other source. In this case the only source available would be the radioactive decay of fission products in the reactor fuel.

Conditions may be envisaged in which it has ceased to be possible to extract heat from inside the sphere. The temperature of the reactor rises. The neutron reaction closes down, but the emission of heat from the decay of fission products continues. In the worst case all this heat might go to evaporating sodium. The burning of the sodium vapour produces twice the amount of heat absorbed in vaporisation. All this heat might be transferred to the air. This, in turn, would transfer heat, by natural convection, to the steel pressure vessel, which would be cooled by the outer air. On these assumptions the air would reach a maximum temperature of 340 deg. C., and a maximum pressure of 16 lb. per square inch some fifteen minutes after the fire started. With some additional allowance for barometric variation and so on, the design figure for the maximum internal working pressure of the sphere has been taken to be 18 lb. per square inch.

EXTERNAL PRESSURE

The internal pressure is not, however, the only criterion to be considered in designing the sphere. After the reaction has gone to completion and all the oxygen in the sphere has been consumed, the temperature would eventually fall,

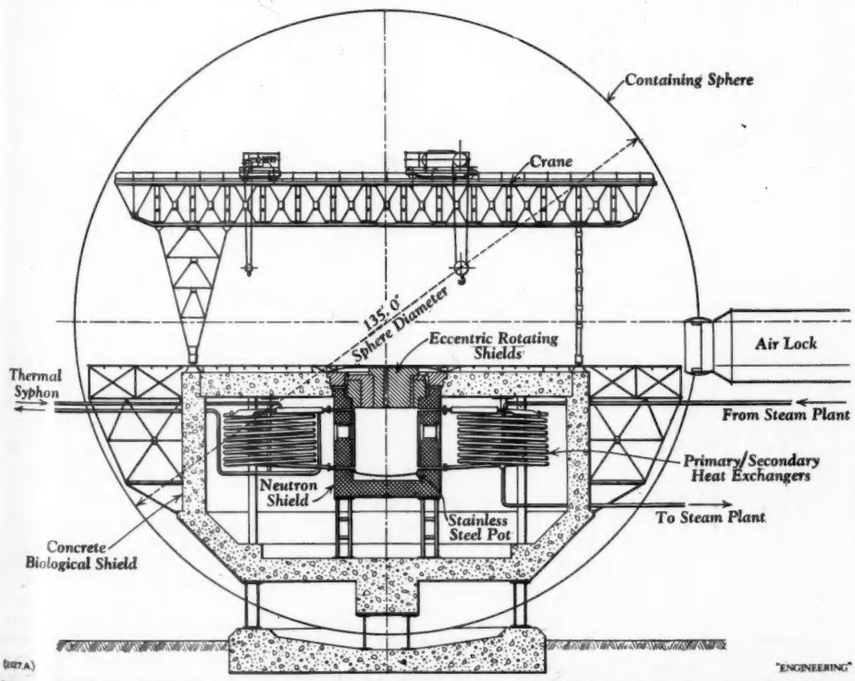


Fig. 2 General arrangement of Dounreay fast reactor. The reactor, which is contained in a spherical pressure vessel as a safety measure, is of an experimental nature and may be easily modified. The coolant removes 60 MW of heat for conversion into electrical power.

leaving a partial vacuum inside. The removal of the oxygen would leave an external excess pressure of 3 lb. per square inch. The pressure at which the sphere would begin to buckle depends on the uniformity of the steel shell. The most pessimistic estimate is that, at 5 lb. per square inch excess external pressure, a shallow dimple some 18 ft. in diameter would appear at the top. This would not raise stresses in the steel greater than 1 ton per square inch. The most unfavourable combination of circumstances could not impose greater pressures than this.

Because reliance is placed on heat transfer from the outside to dispose of heat in the event of an accident, no lagging will be provided on the outside of the sphere and water will be piped to the top so that it can be pumped over the outer surface to assist the removal of heat if need be.

NUCLEAR REACTOR SYSTEMS

PROMISING DESIGNS FOR POWER PRODUCTION

Researches by the United States Atomic Energy Commission have shown that there are five reactor systems which offer most promise for the economical production of electric power. All five schemes are to be employed in the American reactor construction programmes outlined in ENGINEERING *last week (page 232).*

The brief descriptions of the five systems given below have been taken from a paper, "Economics of Nuclear Power," presented by Mr. James A. Lane of the Oak Ridge National Laboratory, Tennessee, to the International Conference on the Peaceful Uses of Atomic Energy on Tuesday, August 9. Mention will also be made of certain other reactor systems, including one designed solely for research and demonstration purposes; a number of British research reactors are listed on page 266.

WATER REACTORS

The reactors which the United States Atomic Energy Commission regards as offering most prospect for the competitive conversion of atomic energy into electric power are: (*a*) the pressurised-water reactor (PWR); (*b*) the boiling reactor (BWR); (*c*) the sodium-graphite reactor (SGR); (*d*) the fast-breeder reactor (FBR); and (*e*) the aqueous homogeneous thorium breeder reactor (TBR). Schematic diagrams of these reactors are shown in Figs. 1 to 5.

In the pressurised-water reactor (Fig. 1), a full-scale version of which is now being constructed by the Atomic Power Division of Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, either heavy water or ordinary water can be used as the coolant and moderator, with appropriate adjustment of the spacing and enrichment of fuel elements. The Westinghouse reactor in fact uses ordinary water. The water is pumped between the solid fuel rods in the reactor core and thence to a heat exchanger where steam is produced to drive a turbine. Since the water in the primary circuit is under pressure it can reach much higher temperatures without boiling. A pressurised-water reactor was described in our issue of last week (pages 228 and 233).

In the boiling-water reactor (Fig. 2), which can also use either heavy or light water, steam is produced directly by allowing boiling to occur within the reactor core. This method of heat removal dispenses with the heat exchanger, has correspondingly higher thermal efficiencies and enables the size of pumps and other equipment to be reduced. Offsetting these advantages are the necessary higher fuel enrichment due to the presence of steam in the core, and the need to enclose the turbine and condenser within a shield owing to the radioactivity of the water. A description of a small boiling-water reactor together with some comments on its use appeared in ENGINEERING last week (page 228).

SODIUM-GRAPHITE AND BREEDER REACTORS

The sodium-graphite reactor (Fig. 3) takes advantage of the high temperatures and high thermal efficiencies to be gained through use of liquid sodium as coolant and graphite as the moderator. Here the primary sodium coolant circulates between solid fuel elements in the reactor and then through a heat exchanger where heat is transferred to a secondary sodium system. As distinct from the primary sodium, which becomes radioactive, the secondary sodium can be circulated outside the shield through a steam generator.

The use of sodium as a high-temperature coolant is also applicable in a case of a fast breeder reactor (Fig. 4). In this case the reactor consists of an unmoderated core, fuelled with plutonium containing some uranium 238, and surrounded by a uranium 238 blanket. Primary sodium is used to cool both the core and the blanket in conjunction with a secondary sodium system, as in the sodium-graphite reactor.

The advantage of the fast breeder system is the high breeding gain (excess of fuel produced over fuel consumed) possible with fast neutrons in the plutonium 239-uranium 238 system, as a result of the lower parasitic capture of neutrons by plutonium 239 itself. On the other hand, fast reactors require a large quantity of nuclear fuel to achieve criticality (the critical concentration of fuel at which a chain reaction can occur), with correspondingly high inventory charges. The British experimental fast breeder reactor at Dounreay is described on page 280 of this issue.

AQUEOUS HOMOGENEOUS REACTOR

The aqueous homogeneous reactor (Fig. 5) employs a dilute solution of uranium 233 (produced by neutron irradiation of thorium: see page 264) in heavy water, which flows through an inner core vessel; in this vessel is generated the major part of the heat. The core is surrounded by a larger pressure vessel through which a suspension of thorium dioxide (ThO_2) in heavy water is circulated; this is known as a "blanket" and the thorium serves for breeding more uranium 233. Both the core solution and blanket suspension are circulated through heat exchangerswhere steam is generated.

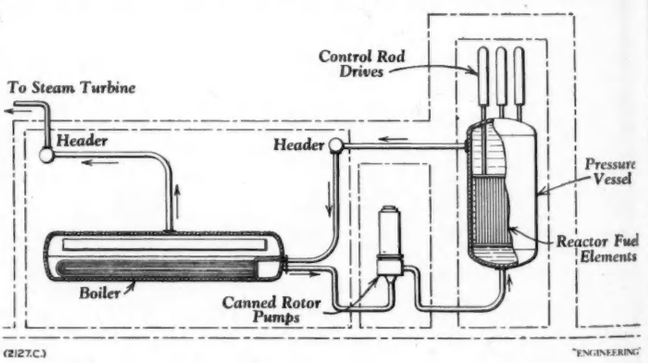
The use of a fluid fuel and blanket enables simpler fuel-processing systems to be employed, and fuel-processing costs are thus minimised. Both the uranium solutions and thorium suspensions, however, are somewhat corrosive and highly radiaoctive, and in general require very special fuel-circulating and heat-removal systems.

One of the major problems in handling aqueous fuel solutions is caused by the decomposition of heavy water in the presence of radiation. The explosive deuterium-oxygen gas mixture thus formed must be separated from the circulating liquid stream, as indicated in Fig. 5, and recombined before being injected back into the system. The pressurisers illustrated serve to maintain a constant volume and prevent boiling in the circulating liquid.

"SWIMMING POOL" REACTOR

An American reactor unsuitable for power production but providing useful research infor-

Fig. 1 In the pressurised-water reactor either heavy or ordinary water can be used as the coolant and moderator. Since it is under pressure the water can reach a high temperature without boiling.



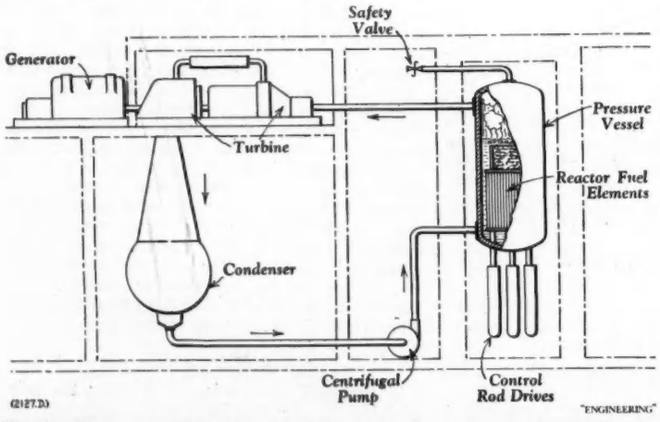


Fig. 2 Heavy or light water can be used in the boiling-water reactor, in which boiling is allowed to occur in the reactor core, so producing steam directly and dispensing with heat exchangers; thermal efficiency is therefore high.

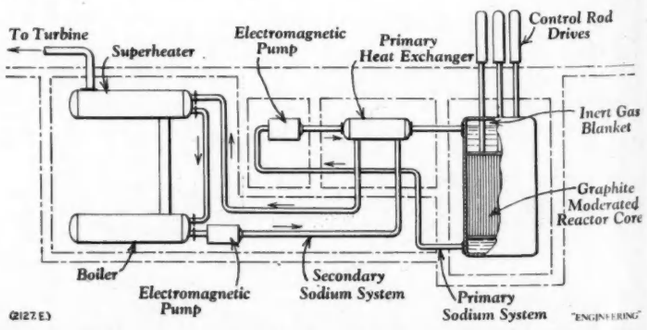


Fig. 3 High temperatures and consequently high efficiencies are possible in a liquid-sodium cooled reactor. The moderator is graphite. A secondary non-radioactive liquid-sodium circuit carries heat to a steam generator.

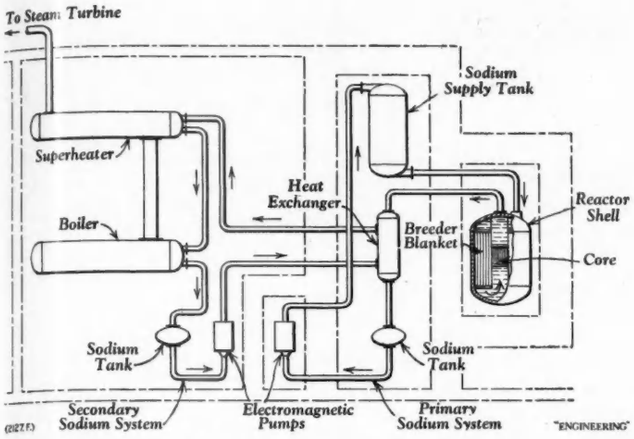


Fig. 4 Sodium can be used as a high-temperature coolant in a fast breeder reactor, which is economical in fuel usage since it produces more nuclear fuel than it consumes.

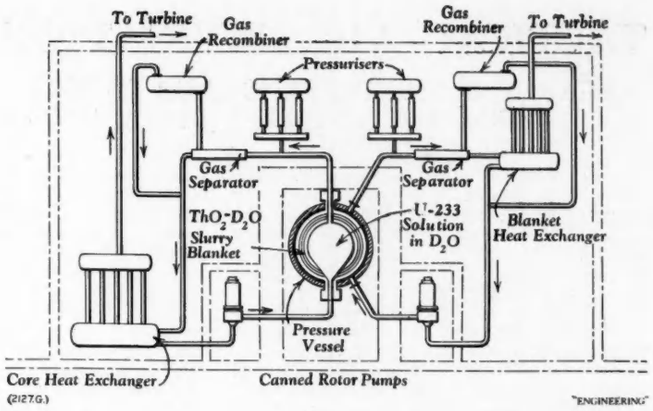


Fig. 5 The aqueous homogeneous reactor uses as fuel a dilute solution of uranium 233 in heavy water contained in a core vessel; surrounding this is an enclosing vessel containing a suspension of thorium oxide in heavy water (the "blanket"), from which more fuel is bred by neutron irradiation.

mation is the "swimming pool" reactor, an example of which was demonstrated at the International Conference in Geneva. This reactor was designed and built at the Oak Ridge National Laboratory, Tennessee, which is operated for the Atomic Energy Commission by the Union Carbide and Carbon Corporation, New York. As can be seen from Fig. 6, which shows the reactor in operation, reactions in the core produce a visible glow; this is known as "Cerenkov radiation."

The reactor consists basically of a large steel tank of water in which the fuel-element assembly is submerged. The water has three functions; it acts as a radiation shield, as a coolant, and as a moderator. The tank of the version demonstrated is 10 ft. in diameter and 22 ft. deep, and holds 13,000 gallons of demineralised water. The reactor body or core is an assembly of movable fuel elements placed vertically in an aluminium grid, and is supported from the bottom of the tank to afford maximum visibility.

The fuel elements in this model, which is designed to operate at a continuous level of 10 kW, contain about 40 lb. of uranium. This uranium has been enriched to 20 per cent. concentration of uranium 235; the balance is non-fissile uranium 238. Although of little use as a power source, the "swimming pool" reactor can produce radioactive isotopes with fairly high activity, and can be used for irradiation purposes.

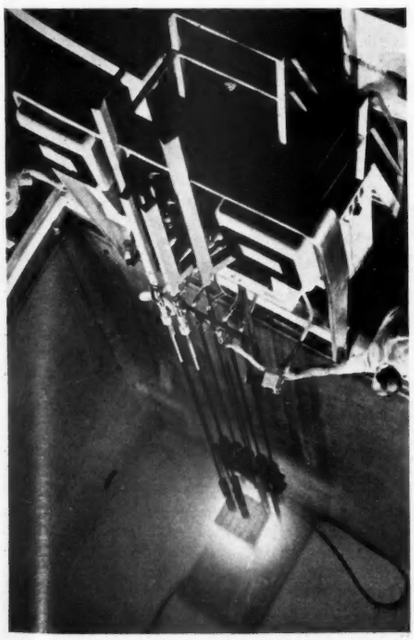


Fig. 6 When operating at its design level of 10 kW, the core of the "swimming pool" reactor produces a visible glow known as "Cerenkov radiation." This reactor, which employs water as shield, coolant and moderator, has been built solely for research and demonstration purposes.

GAS COOLING AND DIRECT CONVERSION

A reactor system which is to be used in Britain for electricity production employs gas cooling; the gas is circulated under pressure through graphite-moderated piles. This system is to be used in the 50-MW* plant at Calder Hall (see page 265 of this issue and page 240 in the issue of February 25) and in this case the coolant gas is carbon dioxide. Though competitive with other sources of power in this country, this system may eventually be superseded by other systems, based on experience gained at Harwell and elsewhere, which will be more efficient in fuel usage and heat conversion.

Finally it is necessary to mention the ideal reactor system. Efficiency might be improved immensely and capital cost reduced if some means of converting nuclear energy directly into electrical power could be found, as light energy is transformed by the photo-electric cell. Investigations have been carried out in this field but so far it has proved only possible to convert small quantities of energy. We hope to publish an abstract of a paper on this subject delivered at the Geneva Conference in a subsequent issue.

* * *

PRODUCTION OF THE FORD "POPULAR"

A stage in the rationalisation of their car production has been carried out recently by the Ford Motor Company, who have moved certain processes in the manufacture of the "Popular" from Dagenham to Doncaster. The Doncaster factory of Briggs Motor Bodies, Limited, which was taken over by Fords two years ago, has always produced certain parts for the Popular. Until July 21 assembly of the Popular was at Dagenham, but to make room for expanded production of Anglias, Prefects, and other models it was decided to move the Popular assembly line to Doncaster. The space at that factory became available due to the run-out of certain Briggs contracts, and the whole change-over, resulting in increased production of Populars, Anglias and Prefects has been done with the construction of only one building.

* Electrical rating. Reactors, as distinct from reactor power stations, are normally specified on heat output, which is much higher than the electrical rating, since the efficiency of conversion is low.

The change-over has meant that a number of men at Doncaster have had to take on different jobs, and this has been done by sending them to Dagenham for three months' training. The output of Populars remained the same until a few days before the transition, when it tailed off as machinery was transferred to Doncaster. After the transition, which took place during the annual two weeks' holiday, full production was expected to be reached again after three or four weeks. New equipment has been installed at the Doncaster factory, including special spray booths, and some equipment was transferred from Dagenham. The result is that now the bodies are made and the car assembled in one factory, a practice at present adopted by few car manufacturers in this country. The engine, transmission, certain other mechanical items, and pressings for the body are still supplied from Dagenham.

* * *

SCIENCE AND MANAGEMENT

B.I.M. Conference in November

Industry is at present being confronted by important developments of many kinds, as a result of recent scientific progress. These developments will have a substantial and lasting effect on living conditions generally and it is recognised that the responsibility for putting the knowledge gained in research laboratories into practical effect in the nation's workshops and factories must rest, in the main, upon managements and administrators.

For these reasons the British Institute of Management has decided that the theme for its forthcoming national conference, the tenth to be held since the Institute's inauguration, shall be "The Impact of Science on Management in the Future." The conference will be held at Harrogate from Wednesday, November 2, to Friday, November 4, next. Speakers will include Mr. John Diebold, an American pioneer of developments in automation, Sir Geoffrey Vickers, V.C., a member of the National Coal Board, and Sir Charles Goodeve, O.B.E., F.R.S., Director of the British Iron and Steel Research Association. It is expected that about a thousand industrialists and managers will attend the meeting as delegates and the arrangements will include two plenary sessions and 24 sectional meetings devoted to specialised aspects of management. The conference fee will be £9.

Preliminary programmes are expected to be available about the middle of next month and advance copies of the papers to be presented will be issued prior to the conference. Applications to attend should be sent as much in advance as possible to the Director, British Institute of Management, 8 Hill-street, London, W.1.

TACTICAL AIR NAVIGATION SYSTEM

BEARINGS AND DISTANCES UP TO 200 MILES RANGE FOR 100 AIRCRAFT SIMULTANEOUSLY

A new system of air navigation, TACAN, evolved in the United States primarily for use by military aircraft, is being developed in the United Kingdom under Ministry of Supply contract by Standard Telephones and Cables, Limited, Connaught House, Aldwych, London, W.C.2, and is at present undergoing trials. TACAN, which has a normal maximum range of 200 nautical miles and operates in the frequency band 962–1215 megacycles, provides continuous information to the pilot showing his bearing and distance from a selected ground station in the form of meter indications. Up to 100 aircraft can be accommodated by each ground station. The Ministry of Supply consider that the TACAN system also offers great possibilities for civil air traffic control.

The chief constituents of the TACAN system, which is very complex in its detail, are a ground beacon transponder and an airborne interrogator/receiver with indicator. The British and American airborne transmitter/receivers are physically and electrically interchangeable.

BEARING INFORMATION

Bearing information is generated in the aerial system of the ground beacon which contains a central radiating array so designed as to produce a field pattern which gives best coverage for the tactical uses envisaged. Around this central array is rotated a system of vertical parasite elements which distort the circular pattern in a sinusoidal fashion. Since the output from the beacon consists of a series of equal-amplitude pulses, the radiated signal will consist of pulses having a superimposed sinusoidal amplitude modulation not exceeding a maximum of 50 per cent. Thus an aircraft at a fixed point in space can, by demodulating the received signal, recover a sine-wave signal corresponding to the aerial rotation. Also in the aerial is a means of producing sharp trigger pulses whenever fixed points on the rotating part of the aerial pass through a given bearing with respect to north compass point. These signals are coded in the beacon into short identifiable pulse trains which are radiated as part of the beacon output signal. These pulse trains, or " marker trains " as they are called, are detected by the airborne equipment and by comparing them with the phase of the sine wave extracted from the aerial rotating pattern, the bearing of the aircraft can be ascertained and indicated directly.

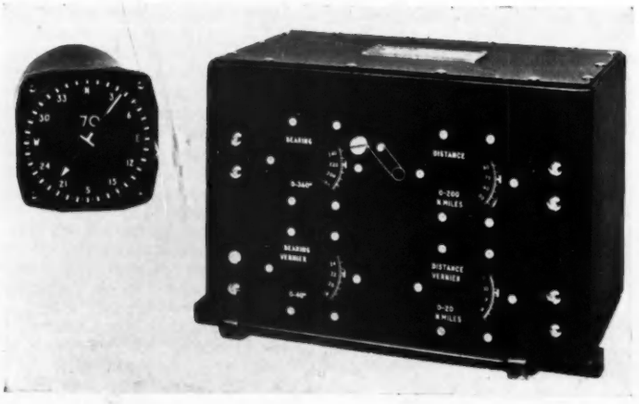
The marker pulse trains are of relatively short duration and in order that the aerial space-modulation pattern can be conveyed to the aircraft, the spaces between the marker pulses are filled with pulses of similar shape but of random repetition rate averaging 2,700 pairs per second—each pair having a spacing of 12 microseconds. The random pulses ensure that no spurious locking-on of the distance-measuring equipment in the aircraft can take place.

In order to increase the bearing accuracy provided, a coarse/fine system is used so that the radiated aerial pattern actually consists of a fundamental sine-wave modulation of 15 cycles, corresponding to the aerial rotation speed of 900 r.p.m., with a superimposed ninth harmonic modulation of 135 cycles. In the aircraft equipment the 15-cycle modulation is used as a gate to select part of the 135-cycle signal and eliminate ambiguity. In conjunction with this, appropriate marker-pulse trains are transmitted every 40 deg. of aerial rotation for phase comparison in the aircraft and these are differently coded from the fundamental pulse train.

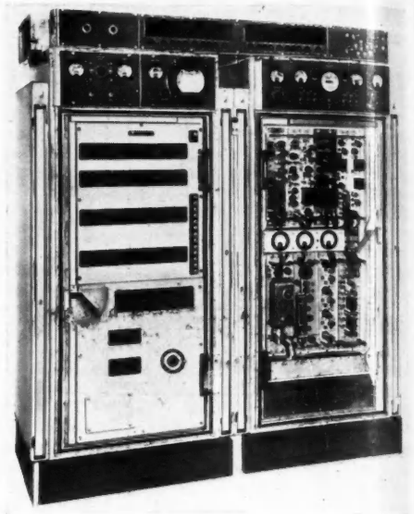
DISTANCE MEASURING INFORMATION

When the aircraft requires range information from the beacon it transmits a signal consisting of pulse pairs spaced at 12 microseconds and at a repetition rate of between 24 and 30 pairs per second on a frequency differing by 63 megacycles from that transmitted by the beacon under interrogation. This signal is received by the beacon receiver and delayed by 50 microseconds and is then re-transmitted, displacing the equivalent number of random pulse pairs. The aircraft receives this reply and distinguishes it from the random pulses by reason of its phase coherence with the signal it is transmitting. The aircraft then determines its range from the beacon by measurement of the time between the transmitted signal and reply, taking into account the known fixed delay in the beacon. If the beacon response to an interrogation coincides with the time when a bearing-information marker train is transmitted, this latter takes precedence and the reply to the interrogation is suppressed. This, however, happens infrequently and the airborne equipment has sufficient memory to enable it to work satisfactorily if it receives replies to only 50 per cent. of its interrogations. As more and more aircraft interrogate the beacon simultaneously, so more random pulses are displaced by replies until at full beacon capacity, i.e., 100 aircraft interrogating simultaneously, very few random pulses are transmitted. Each aircraft recognises its own replies by virtue of the fact that the rate of interrogation from each aircraft is slightly different and therefore only its own reply will have sufficient phase coherence to enable the distance-measuring circuits to lock on.

It is desirable to have a large number of operational channels so that an adequate number of beacons can be placed in a given area without mutual interference, and the TACAN system provides 126 channels spaced 1 megacycle apart.



The TACAN airborne visual indicator is seen on the left. The needle indicates bearing and the Veeder counter the distance in nautical miles. On the right is the airborne range and bearing computer.



The TACAN system operates in the frequency band 962-1215 megacycles, and comprises essentially a ground beacon transponder and an airborne interrogator/receiver with indicator. Shown here is the ground-beacon cabinet with the outer door retracted. Each ground beacon can serve up to 100 aircraft.

This close spacing of the channels necessitates the use of special techniques, including the transmission by the ground beacon of pulses shaped so as to have minimum side-band energy content, and the provision in both ground and airborne equipments of special adjacent channel-rejection circuits.

GROUND BEACON AND AIRBORNE EQUIPMENT

The beacon installation consists of the beacon cabinet, shown in the above illustration containing electronic, air conditioning and test equipment, the aerial, and the aerial control cabinet. The transmitter can be tuned to any one of 126 channels spaced 1 megacycle apart in the frequency bands 962 to 1,024 megacycles and 1,151 to 1,215 megacycles. The accuracy of the output frequency is 50 parts in 10^6 and is controlled by a quartz crystal in a temperature-stabilised oven. The receiver can be tuned to any one of 126 channels spaced 1 megacycle apart in the band 1,025 to 1,150 megacycles, and this frequency will always be 63 megacycles away from the transmitter frequency. The output power of the transmitter is 7 kW peak minimum.

The beacon is designed to operate from a 400/440 three-phase supply at any frequency between 45 and 65 cycles. The total power consumption is approximately 10 kVA.

The airborne installation includes a 126-channel transmitter/receiver, a pilot-operated remote-control unit, a range and bearing computer, a visual indicator, and a single " shark-fin " antenna. The computor and the indicator are shown in the illustration on the left.

The visual indicator presents distance information on a Veeder counter and the bearing on a normal 360-deg. dial. The single " shark-fin " antenna is used for transmission and reception. Any one of the 126 radio-frequency channels can be selected by the pilot from the remote-control unit. Power supplies required for the airborne equipment are 115 volts 400 cycles and 28 volts direct current. The total weight of the airborne equipment is approximately 70 lb.

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The assumed cost of the 400-h.p. Diesel locomotive referred to on page 141, column 3, line 17, of our issue of July 29, in the article on " Raising Efficiency of Works Rail Transport," should have been £22,000 not £32,000.

STEEL TUBE POLE FOR TRANSMISSION LINES

Simple Construction Suitable for Overseas Erection

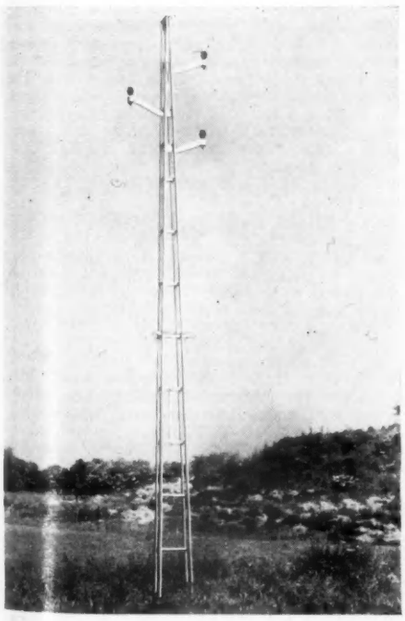
A new pole for use on overhead transmission and distribution lines, where heavy mechanical loading is not present, has been developed by Messrs. Painter Brothers, Limited, Hereford, in collaboration with British Insulated Callender's Construction Company, Limited, 21 Bloomsbury-street, London, W.1.

This pole, which will be known as the P.N. pole, is shown in the accompanying illustration. Economy, lightness and simplicity of construction have been achieved by fabricating it from standard commercial sizes of small-bore steel tubing and by adopting a bracing system, which allows the complete pole to be separated into its component parts. This facilitates transportation and enables assembly and erection to be carried out by a minimum of skilled labour.

The P.N. pole is made of four steel tubes with a nominal bore of 1 in. and walls of 12-s.w.g. thickness, to Class A, British Standard 1,387. On the longitudinal faces the tubes are connected at intervals by batten plates. These plates are welded to the tubes and are also bolted to spacers of rolled steel flats to form I sections. These sections connect together the two longitudinal frames which make the complete pole. The two longitudinal faces are fastened together at the top by a locking unit and cap plate, which are connected by a through bolt or insulator spindle. The cap plate also serves to seal the ends of the tube from the atmosphere. All the structural parts are hot-dip galvanised and the bolts are hot-dip spun galvanised. The tubes are left open during the galvanising process so that both their insides and outsides are protected.

The pole is either 30 ft. or 35 ft. long overall and is designed for a depth below ground level of either 5 ft. or 5 ft. 6 in. As will be seen, the transverse face tapers from ground line to peak to form an A-frame, and a reverse taper below ground provides an efficient foundation. It has been designed for an ultimate head load of not more than 1,250 lb. at the top and has been subjected to full-scale tests and its strength proved.

The pole is regarded as being particularly suitable for tropical conditions and for spacings between 250 and 350 ft. depending on the size and material of the conductors. It will be appreciated, however, that it is not suitable for use as a strut. It cannot therefore be used as a stayed structure, although it has been successfully tested at angle and terminal positions.



Steel tube pole for electric transmission lines.

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SELF-CONTAINED CARBONITRIDING AND HEAT-TREATING FURNACE

A complete furnace installation for the case-hardening of a wide variety of low-carbon steel parts such as bearings, instrument parts, seamless tubes, gear blanks and bevelled gears, and nuts and screws, has recently been placed on the market by the Electric Resistance Furnace Company, Limited, Netherby, Queen's Road, Weybridge, Surrey.

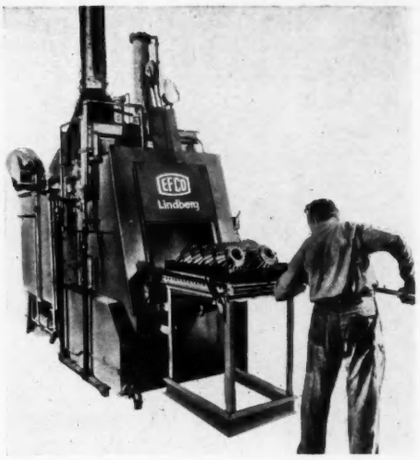
The EFCO-Lindberg carbonitriding furnace, as it is called, consists of a gas-fired vertical radiant tube heating chamber, a built-in oil-quench tank, a purge chamber, an atmosphere cooling chamber, and a separate gaseous generator. The latter is the EFCO endothermic atmosphere generator which is used, not only for carburising, but also for annealing, hardening, carbon restoration and other operations. The basic gas is produced by the cracking of town gas, with air. Ammonia and a hydrocarbon gas such as propane are added to the generator gas in proportions which are varied according to the physical properties required in the case formed on the steel article. When it is desired to carry out neutral hardening the ammonia and hydrocarbon gases are shut off and the basic generator gas is used alone.

The furnace chamber is equipped with a roller conveyor and is heated by eight lightweight thin-wall vertical radiant tubes, each weighing 29 lb. only and easy to change when necessary. The controlled atmosphere inlet tube is in the roof of the furnace and an atmosphere-circulating fan, mounted below the heating chamber provides a constant and even circulation of the furnace atmosphere through the work load, ensuring uniformity of temperature and of depth of case. The lining of the furnace chamber consists of heavy firebricks and the internal measurements are 24 in. wide by 36 in. deep by 15 in. high.

In the purge chamber, in front of the furnace chamber and, like the latter, fitted with rapidly working air-operated doors protected with a flame curtain to prevent contamination, the charge is thoroughly purged of air to prevent contamination of the furnace atmosphere. The quenching tank is below the purge chamber and has a capacity of 375 gallons of oil, the temperature of which is controlled by a fin-type oil cooler mounted directly in the tank. Plant water is used as the cooling agent. An agitating motor-driven propeller gives a positive flow of oil through the work load while it is in the quenching position. Among other advantages, the built-in quenching tank minimises distortion because oil quenching takes place within the furnace structure and heated charges are not exposed to the air.

Situated at the top of the purge chamber is the water-jacketed atmosphere cooling chamber which allows the furnace to deal with the heat-treatment of air-hardening steels and with stress-relieving and annealing operations. By means of a two-deck elevator the work load can be cooled in a protective atmosphere while another load is being heated in the furnace.

Three types of carbonitriding furnaces are available, namely manual loading with automatic cycle and quench, manual operation with power push, and completely manual operation. In the first type, after the work has been pushed into the heating chamber, the heating cycle and oil quenching are carried out automatically. In the second design, incorporating manual operation with power push, a timer signals the completion of the heating cycle and the operator, by using a pushbutton, transfers the work from the furnace chamber on to the elevator. In the third type the equipment is completely manually operated.



EFCO-Lindberg carbonitriding furnace, showing work being pushed through the flame curtain into the purge chamber in front of the furnace chamber.

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PURIFYING SALT WATER

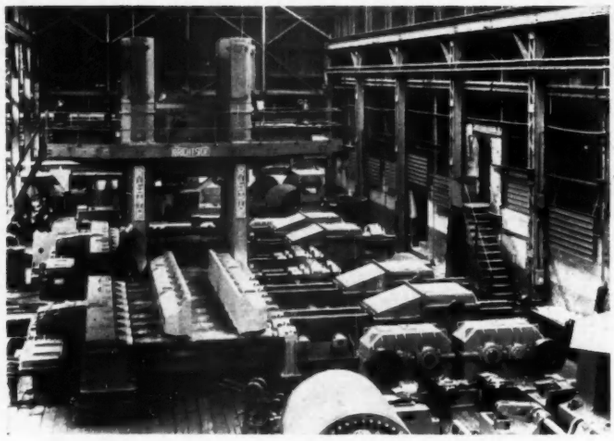
Electrodialysis and Other Methods

In many parts of the world a shortage of readily available fresh water is gradually increasing, and authorities in places as far apart as Norway and Australia, Hongkong and San Francisco are discovering that they may soon have to think of using brackish water, perhaps even sea water. Great Britain is no exception, in spite of its rainfall. For instance, seawater is infiltrating into fresh water wells in the Thames estuary and it is becoming more and more difficult to suggest other sources that do not involve expensive, long-distance pumping. It is clear that research for turning brackish water into fresh is going to grow in importance.

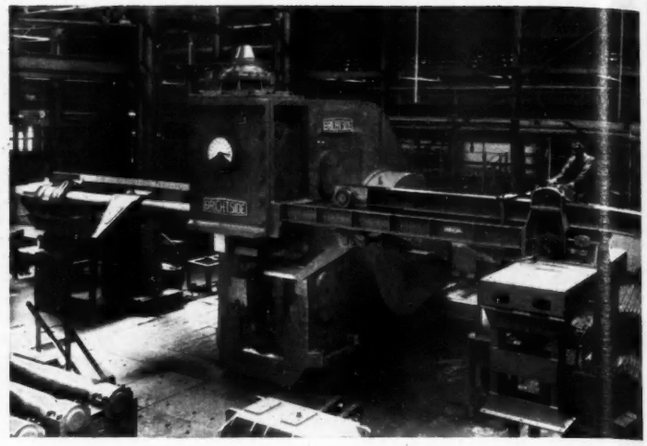
Talks on the possibilities of various methods of de-salting water have been going on for some time under the auspices of O.E.E.C. One promising process is electrodialysis—the removal of salts from a liquid flowing between pairs of ion-selective membranes, by means of an electric field. Research on this method is already well advanced in the Netherlands, and the Dutch recently offered to carry out development work in co-operation with other countries showing an interest. Great Britain has joined the Netherlands, South Africa, Australia and Algeria (representing France) in paying for this work and it has now begun. The problems to be solved are mainly those of bringing up the process from small to large pilot plant scale. All the co-operating countries will share in the new knowledge and any patents that may be taken out in the future. Results which the previous Dutch work produced will also be shared between them. Manufacturing rights in any large-scale process will be available to industry on reasonable terms.

In this country, an Admiralty team has been working on scale and foam prevention in methods of distillation, a well established process. Outstanding results have been achieved in the Navy but the Admiralty, of course, has been working with seawater exclusively. The Department of Scientific and Industrial Research has now given £5,000 to pay for an extension of the programme to cover other waters.

Still in the exploratory stage are two other processes which the French have put forward as possibilities for co-operative research. These are certain aspects of ion-exchange and of solar distillation, which may be suitable for use in very hot, dry areas. No co-operative group to study these has yet been formed.



The roller table and manipulator gear on the outgoing side of the Brightside 34-in. blooming and slabbing mill.



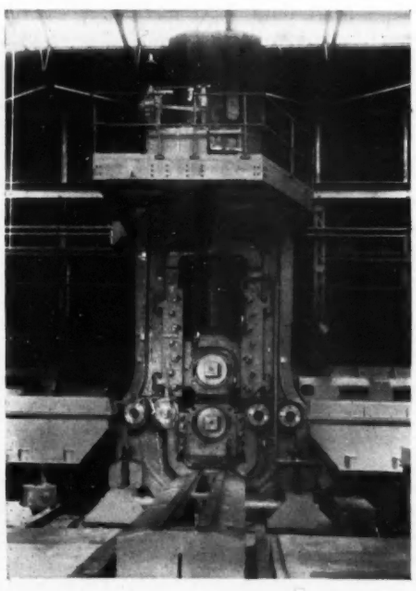
Front view of up-cutting bloom and slab shear, which has a blade load of 800 tons, and is complete with bloom-measuring gear and crop-end pusher.

STEEL ROLLING PLANT FOR TURKEY

34-IN. REVERSING MILL FOR BLOOMS AND SLABS

The slabbing and blooming mill illustrated herewith has been built for the Sumerfield General Directorate, Ankara, Turkey, and will be installed at the Karabuk Iron and Steel Works. The Brightside Foundry and Engineering Company, Limited, Sheffield, 1, have been responsible for the design and construction of the whole of the mechanical equipment, the consulting engineers being the International Construction Company, Limited, 56 Kingsway, London, W.C.2. The electric drive and control gear, which is also of British manufacture, has been the subject of a separate contract. Operating 16 shifts per week and 50 weeks per year, the mill will have an output of 400,000 tons per annum. It will roll ingots three tons in weight, the mean square dimension being 20½ in., for the production of blooms from 6 in. to 12 in. square. For slab production the mill will work on ingots 36 in. by 12 in., and the slabs will be rolled up to 30 in. wide by 5 in. thick.

The complete equipment comprises approach, working and run-out tables; the mill, which has a nominal size of 34 in., is equipped with sideguard manipulators; an ingot weighing and turning device; a hot-cropping and dividing shear with a stop and measuring gear; a slab pusher and transfer bed; and tables and transfer gear for feeding the blooms to an existing 28 in. structural mill. This feed can be either direct from the 34 in. mill to the structural mill, or via a wash-heating furnace as required. The run-out table is designed to allow the blooms to be side-transferred to a skid-bed for charging into the wash-heat furnace, from which they are removed and delivered to the structural mill over tables and transfer gear. All the roller tables are driven through line-shafts and mitre gears, and forged or cast rollers are used according to their position in the mill and the duty for which they are intended. The table rollers and drives all run in roller bearings, and are of frame and unit construction. On the approach table for the 34-in. mill there is an overhead ingot weighing machine with an automatic weight recorder. This machine is incorporated in the lifting and turning device which enables the ingot to be turned either large-end or small-end foremost as required. An operating pulpit is located adjacent to the lifting and turning unit.



End view of mill stand, showing the power-operated sledge for roll-changing.

The mill train has 36-in. diameter rolls, 84 in. long in the barrel, running in fabric bearings lubricated by water. The drive is by universal spindles and a pinion housing of 41½-in. centres from a direct-current reversing motor of 14,000 peak h.p. at 60 r.p.m. The cut-out peak is 16,100 h.p. at the same speed. The mill speed is 0/60/150 r.p.m. A maximum lift of 36 in. is provided for the rolls, which are powered for a screwing speed of 160 in. per minute. The top roll is balanced by opposed screws, and Brightside patented quick-release gear is fitted to facilitate roll-changing. Both rolls are changed simultaneously, being withdrawn from and entered into the housings by a power-operated sledge. The manipulators are of the full sideguard type, and are fitted with tilting fingers on the ingoing side. They are designed to handle blooms down to 6 in. square minimum from the 20½ in. mean square ingots, and all sizes of slab rolled by the mill. The manipulators are powered to give a traversing speed of 164 ft. per minute, and incorporate patented tilting finger drive.

On the outgoing side of the mill there is a hot bloom shear of the down-adjusting, up-cutting type, electrically driven, and powered for a blade load of 800 tons. It has a maximum daylight between the blades to suit 12-in. blooms, and a blade width to accommodate slabs 30 in. wide. It is equipped with a power-driven crop-end pusher and a retractable roller to allow the crops to fall freely into collecting bins by way of a chute and butterfly switch. A stop and measuring gear is provided, electrically powered for both lifting and traversing. It is calibrated to measure blooms of any length from 1·25 m. to 5·5 m. A pusher and transfer bed for slabs are located immediately behind the shear.

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LAUNCHES AND TRIAL TRIPS

S.S. "ATLANTIC SANTOS."—Single-screw oil tanker, with accommodation for a small number of passengers, built and engined by Société Anonyme John Cockerill, Hoboken, Belgium, for the Eastern Trading Co., Monrovia, Liberia. Main dimensions: 558 ft. by 70 ft. by 40 ft.; deadweight capacity, about 18,700 tons on a draught of 30 ft. 6 in. Cockerill-Westinghouse geared steam turbines, developing 16¾ knots. Launch, August 3.

M.S. "FERNBANK."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for Fearnley & Eger, Oslo, Norway. Main dimensions: 450 ft. between perpendiculars by 64 ft. by 41 ft. to shelter deck; deadweight capacity, about 9,900 tons on a draught of 28 ft. Eriksbergs-B. and W. eight-cylinder single-acting two-stroke Diesel engine, developing 10,000 b.h.p. and arranged to operate on heavy oil. Service speed, 17¾ knots. Launch, August 8.

M.S. "KAWERAU."—Single-screw cargo vessel, built and engined by Alexander Stephen and Sons, Ltd., Glasgow, for the New Zealand to Australia service of the Union Steam Ship Co. of New Zealand, Ltd., London, E.C.3, and Wellington, New Zealand. Main dimensions: 325 ft. by 50 ft. by 26 ft.; deadweight capacity, about 5,300 tons. Stephen-Sulzer six-cylinder single-acting Diesel engine, developing 2,410 b.h.p. at 128 r.p.m. in service. Launch, August 16.

M.S. "SAMUEL ARMSTRONG."—Single-screw grab hopper dredger, built by Henry Robb, Ltd., Leith, to the order of the Ipswich Dock Commission, Ipswich, for service at Ipswich Docks and on the River Orwell. Main dimensions: 135 ft. overall by 28 ft. 6 in. by 12 ft. to upper deck; hopper capacity, 300 cub. yd. on a mean draught of 10 ft. 6 in. Equipped with one Diesel grab-dredging crane, having a maximum radius of 30 ft. and capable of working to a depth of 50 ft. below water level, constructed by Priestman Brothers, Ltd., Hull. Propelling machinery: one two-stroke Diesel engine, developing 700 b.h.p. at 350 r.p.m., constructed by Crossley Brothers, Ltd., Manchester. Loaded speed, 10 knots. Launch, August 18.

M.S. "BURWAH."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for Australian Steamships Proprietary Ltd. (Managing Agents: Howard Smith Ltd.), Sydney, Australia. Main dimensions: 290 ft. between perpendiculars by 44 ft. 6 in. by 20 ft. 10 in.; deadweight capacity, 3,450 tons. Nine-cylinder Diesel engine, developing 1,440 b.h.p., constructed by British Polar Engines Ltd., Glasgow, and installed by the shipbuilders. Launch, August 18.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of forthcoming exhibitions and conferences not included below may have appeared in ENGINEERING, *June 24, page 807; or July 29, page 159. Organisers are invited to send to the Editor particulars of forthcoming events as soon as arrangements are made.*

*PRODUCTIVITY EXHIBITION.—Thurs., Aug. 25, to Sat., Sept. 3, at St. George's Hall, Lime-street, Liverpool. Apply to that address. Tel. Royal 3752.

BRITISH ASSOCIATION MEETING.—Wed., Aug. 31, to Wed., Sept. 7, at Bristol. Apply to the secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 2109. See ENGINEERING, February 11, page 168.

ENGINEERING, MARINE, WELDING AND FOUNDRY TRADES EXHIBITION (20TH).—Thurs., Sept. 1, to Thurs., Sept. 15, at Olympia, London, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, London, W.C.2. Tel. WHItehall 0568.

LEIPZIG INTERNATIONAL FAIR.—Autumn Fair: Sun., Sept. 4, to Fri., Sept. 9. Apply to Leipzig Fair Agency, 127 Oxford-street, London, W.1. Tel. GERrard 0357.

*FARNBOROUGH FLYING DISPLAY AND EXHIBITION.—Mon., Sept. 5, to Sun., Sept. 11, at Farnborough, Hampshire. Open to the public on Fri., Sat. and Sun., Sept. 9, 10 and 11, only. Organised by Society of British Aircraft Constructors, Ltd., 32 Savile-row, London, W.1. Tel. REGent 5215.

MATHEMATICAL COLLOQUIUM, BRITISH.—Tues., Sept. 6, to Thurs., Sept. 8, at Exeter. Apply to Secretary, 7th British Mathematical Colloquium, University College of the South-West of England, Exeter. Tel. Exeter 4141.

CHICAGO EXHIBITIONS.—Tues., Sept. 6, to Sat., Sept. 17. Metal-Working Machinery and Equipment at the Coliseum; Machine Tools at the International Amphitheatre; and Production Equipment at the Navy Pier. Organisers: Exhibition and Convention Management, Inc., 2689 East Overlook-road, Cleveland 6, Ohio, U.S.A.

*SUSSEX INDUSTRIES EXHIBITION AND TRADE FAIR, 9TH ANNUAL.—Wed., Sept. 7, to Sat., Sept. 17, at Corn Exchange, Brighton. Organised by the Federation of Sussex Industries Ltd., 32 Duke-street, Brighton 1. Tel. Brighton 26189.

GHENT INTERNATIONAL FAIR, INCLUDING PRINTING AND PUBLISHING TRADES EXHIBITION and QUINQUENNIAL EXHIBITION OF SCIENTIFIC AND INDUSTRIAL LABORATORY EQUIPMENT.—Sat., Sept. 10, to Sun., Sept. 25, at Ghent, Belgium. *Agents:* S. R. Tippett & Co., Ltd., 110 Cannon-street, London, E.C.4. Tel. MANsion House 4500.

WELDING, INTERNATIONAL INSTITUTE, ANNUAL ASSEMBLY.—Sun., Sept. 11, to Sat., Sept. 17, at Zürich. Apply to the Offices of the Institute, 2 Buckingham Palace-gardens, London, S.W.1. Tel. SLOane 9851.

LIBRARIES AND DOCUMENTATION CENTRES CONGRESS.—Sun., Sept. 11, to Sun., Sept. 18, at Brussels. Information obtainable from Aslib, 4 Palace-gate, London, W.8. Tel. WEStern 6321.

*VIENNA AUTUMN TRADE FAIR.—Sun., Sept. 11, to Sun., Sept. 18, at Vienna. Apply to British-Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

*CZECHOSLOVAK ENGINEERING EXHIBITION.—Sun., Sept. 11, to Sun., Oct. 9, at Brno. Apply to Czechoslovak Commercial Attaché, 6 Upper Belgrave-street, London, S.W.1, (Tel: SLOane 0691); or to Chamber of Commerce of Czechoslovakia, Ul. 28, Rijna 13, Prague.

GAS SALES AND SERVICE CONFERENCE (FOURTH).—Mon., Sept. 12, to Wed., Sept. 14., at the Heads of Ayr Holiday Camp, Ayr, Scotland. Organised by the Gas Council, 1 Grosvenor-place, London, S.W.1. Tel SLOane 4554. See ENGINEERING, August 19, page 232.

INSTRUMENT EXHIBITION AND CONFERENCE (10TH ANNUAL).—Mon., Sept. 12, to Fri., Sept. 16, at the Shrine Exposition Hall, Los Angeles. Sponsored by the American Society of Mechanical Engineers. Organised by the Instrument Society of America, 3443 South Hill-street, Los Angeles 7, California, U.S.A.

INFORMATION THEORY, 3RD SYMPOSIUM.—Mon., Sept 12, to Sat., Sept. 17, in London. Apply to Dr. E. Cherry, M.Sc., Imperial College of Science and Technology, Prince Consort-road, London, S.W.7. Tel. KENsington 4861.

ELECTROMAGNETICALLY-ENRICHED ISOTOPES (CONFERENCE).—Tues., Sept. 13, to Fri., Sept. 16, at the Atomic Energy Research Establishment, Harwell, Berks. Tel. Abingdon 620. See ENGINEERING, March 11, page 321.

CAVITATION IN HYDRODYNAMICS, SYMPOSIUM.—Wed., Sept. 14, to Sat. Sept. 17, at Teddington. Apply to the Director, National Physical Laboratory, Teddington, Middlesex. Tel. Molesey 1380.

ELECTRICAL ENERGY CONGRESS.—Mon., Sept. 19, to Fri., Sept. 23, Church House, Dean's Yard, London, S.W.1. Tenth congress of the International Union of Producers and Distributors of Electricity (UNIPEDE). Apply to the Public Relations Officer, British Electricity Authority, Winsley-street, London, W.1, Tel. MUSeum 4040; or to the Information Department, North of Scotland Hydro-Electric Board, 16 Rothesay-terrace, Edinburgh, 3. Tel. Edinburgh Central 1361. See ENGINEERING, January 21, page 71.

ELECTRICAL POWER, INTERNATIONAL UNION OF PRODUCERS AND DISTRIBUTORS OF.—Mon., Sept. 19, to Sun., Sept. 25, meeting, in London. Apply to the secretary of the Union, 12 Place des Etats-Unis, Paris 16e.

MINERAL RESOURCES STRATEGY, SYMPOSIUM.—Thurs., Sept. 22, in London. Organised by the Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. Tel. NATional 0621. See ENGINEERING, July 22, p. 128.

*HANDICRAFTS, HOMECRAFTS AND HOBBIES EXHIBITION, 3RD INTERNATIONAL.—Thurs., Sept. 22, to Sat., Oct. 1, at Earl's Court, London, S.W.5. Apply to exhibition offices, 24 Store-street, London, W.C.1. Tel. MUSeum 9792.

ASLIB ANNUAL CONFERENCE.—Fri., Sept. 23, to Mon., Sept. 26, at Blackpool. Apply to Aslib offices, 4 Palace-gate, London, W.8. Tel. WEStern 6321.

PETROLEUM AND MECHANICAL ENGINEERING CONFERENCE.—Sun., Sept. 25, to Wed., Sept. 28, at New Orleans. Organised by the American Society of Mechanical Engineers, 29 West 39th-street, New York 18.

*INTERNATIONAL GAS UNION, 6TH CONFERENCE.—Sun., Sept. 25, to Fri., Sept. 30, at Hotel New Yorker, New York. Organised by American Gas Association, 420 Lexington-avenue, New York, 17, U.S.A.

IRON AND STEEL ENGINEERS, ASSOCIATION OF (AMERICAN).—*Annual Convention:* Mon., Sept. 26, to Thurs., Sept. 29, at Chicago. Apply to Association of Iron and Steel Engineers, Empire Building, Pittsburg 22, Pa., U.S.A.

*WATCH AND JEWELLERY FAIR, INTERNATIONAL.—Mon., Sept. 26, to Fri., Sept. 30, at Royal Albert Hall, Kensington, London, S.W.7. Organised by National Trade Press, Ltd., Drury House, Russell-street, London, W.C.2. Tel. TEMple Bar 3422.

ANALOGUE COMPUTING, INTERNATIONAL CONFERENCE.—Tues., Sept. 27, to Sat., Oct. 1, at Brussels. Apply to Mr. P. Germain, Institut de Physique Appliquée, Université Libre de Bruxelles, 50 Avenue Franklin Roosevelt, Brussels.

NATIONAL SMOKE ABATEMENT SOCIETY'S ANNUAL CONFERENCE.—Wed., Sept. 28, to Fri., Sept. 30, at Bournemouth. Apply to Society's offices: Palace Chambers, Bridge-street, London, S.W.1. Tel. TRAfalgar 6836.

TURIN INTERNATIONAL TECHNICAL EXHIBITION (FIFTH), also 7TH AGRICULTURAL ENGINEERING EXHIBITION and 15TH ENGINEERING EXHIBITION.—Wed., Sept. 28, to Sun., Oct. 9, in Turin. Exhibition offices: Via Massena, Turin, Italy.

*REGIONAL PLANNING AND DEVELOPMENT, INTERNATIONAL CONFERENCE.—Thurs., Sept. 29, to Sun., Oct. 2, at Bedford College for Women, Regent's Park, London, N.W.1. Organised by Association for Regional Planning and Development. Apply to Mr. N. J. Hart, 45 Northcote-avenue, London, W.5.

ALL-BRITISH TRADE FAIR.—Thurs., Sept. 29, to Sun., Oct. 16, in the Tivoli Gardens and the Forum, Copenhagen, Denmark. Inquiries to the British Overseas Fairs, Ltd., 21 Tothill-street, London, S.W.1. Tel. WHItehall 6711. See ENGINEERING, July 16, 1954, page 69.

AUTOMOTIVE ENGINEERS, SOCIETY OF.—*Aircraft Production Forum and Aircraft Engineering Display:* Tues., Oct. 11 to Sat., Oct. 15, at Los Angeles. *Transportation Meeting:* Mon., Oct. 31, to Wed., Nov. 2, at St. Louis Miss. *Diesel Engine Meeting:* Wed., Nov. 2, to Fri., Nov. 4. Apply to the Society of Automotive Engineers, 29 West 39th-street, New York, 18.

*ENGINEERING INDUSTRIES ASSOCIATION: LONDON REGIONAL DISPLAY.—Wed., Oct. 12, to Fri., Oct. 14, at Royal Horticultural Society's New Hall, Greycoat-street London, S.W.1. Apply to the secretary of the Association, 9 Seymour-street, London, W.1. Tel.: WELbeck 2241.

*FUEL EFFICIENCY EXHIBITION.—Wed., Oct. 12, to Sat., Oct. 22, at City Hall, Manchester, under auspices of Combustion Engineering Association and National Industrial Fuel Efficiency Service. Organisers: Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

*OFFICE EQUIPMENT, 6TH INTERNATIONAL EXHIBITION.—Thurs., Oct. 13, to Sun., Oct. 23, at Parc des Expositions, Porte de Versailles, Paris. Organised by the Salon International de l'Equipement de Bureau, 6 Place de Valois, Paris.

*SOLID FUELS CONFERENCE.—Wed., Oct. 19, to Fri., Oct. 21, at Neil House, Columbus, Ohio. Organised jointly by American Society of Mechanical Engineers and American Institute of Mining and Metallurgical Engineers. Apply to conference offices, 1672 Barrington-road, Columbus, 21, Ohio, U.S.A.

*MOTOR SHOW (40TH INTERNATIONAL MOTOR EXHIBITION).—Wed., Oct. 19, to Sat., Oct. 29, at Earl's Court, London, S.W.5. Organised by Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

*PLANT ENGINEERS' SCOTTISH CONFERENCE.—Fri., Oct. 21, to Sun., Oct. 23, at Dunblane Hydropathic Hotel, Perthshire. Organised by Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. Tel. Solihull 3021.

*BELFAST BUSINESS EFFICIENCY EXHIBITION.—Mon., Oct. 31, to Sat., Nov. 5, at King's Hall, Belfast. Organised by the Office Appliance and Business Equipment Trades Association, 11–13 Dowgate-hill, London, E.C.4. Tel CENtral 7771.

*IMPACT OF SCIENCE ON MANAGEMENT IN THE FUTURE, CONFERENCE.—See page 283.

*PROTECTIVE EQUIPMENT CONFERENCE.—Fri., Nov. 4, at the London School of Hygiene and Tropical Medicine, Keppel-street, London, W.C.1. Organised by the British Occupational Hygiene Society. Apply to Mr. D. Turner, Medical Research Council Laboratories, Holly-hill, London, N.W.3. See ENGINEERING, August 19, page 253

*WORK STUDY CONFERENCE.—Fri. and Sat., Nov. 4 and 5, at St. Ermin's Hotel, Caxton-street, London, S.W.1, on " Aids to Effective Production Management." Organised in conjunction with Work Study Society by Society of Industrial Engineers, 28 Victoria-street, London, S.W.1.

*SCOTTISH MOTOR EXHIBITION.—Fri., Nov. 11, to Sat., Nov. 19, at Glasgow. Organised by Scottish Motor Trade Association Ltd., 3 Palmerston-place, Edinburgh, 12. Tel. Central 3643.

*CYCLE AND MOTOR CYCLE SHOW, 30TH INTERNATIONAL.—Sat., Nov. 12, to Sat., Nov. 19, at Earl's Court, London, S.W.5. Organised by British Cycle and Motor Cycle Manufacturers' and Traders' Union, Ltd., The Towers, Warwick-road, Coventry. Tel. Coventry 62511.

AUTOMATION EXPOSITION (SECOND INTERNATIONAL).—Mon., Nov. 14, to Thurs., Nov. 17, at the Navy Pier, Chicago. Organised by Richard Rimbach Associates, 845 Ridge-avenue, Pittsburg 12, Pa., U.S.A.

CHICAGO EXPOSITION OF POWER AND MECHANICAL ENGINEERING.—Mon., Nov. 14, to Fri., Nov. 18, at the Coliseum, Chicago, Ill., U.S.A., under the auspices of the American Society of Mechanical Engineers. Apply to the International Exposition Co., 480 Lexington-avenue, New York 17, U.S.A.

CHEMICAL INDUSTRIES EXPOSITION.—Mon., Dec. 5, to Fri., Dec. 9, at the Commercial Museum and Convention Hall, Philadelphia, Pa., U.S.A. Organised by the International Exposition Co., 480 Lexington-avenue, New York 17.

BRITISH INDUSTRIES FAIR.—Wed., Feb. 22, to Fri., Mar. 2, 1956 (including British Toy Fair), at Earl's Court, London, S.W.5. (Organised jointly with British Toy Manufacturers' Association). Also Mon., April 23, to Fri., May 4, 1956, at Olympia, London, W.14, and at Castle Bromwich, Birmingham. Apply to British Industries Fair, Ltd., 9 Kingsway, London, W.C.2. (Tel. COVent Garden 1461); or to general manager, B.I.F., 95 New-street, Birmingham, 2 Tel. Midland 5021.

Labour Notes

LABOUR COSTS SINCE 1948

An interesting and novel analysis of labour costs and their relation to output has been published by the Treasury in the current issue of *Bulletin for Industry*. We are given the usual warning that the figures are estimates and subject " to wide and varying margins of error," but told that they are adequate to show " the general trends over a period." Even so, the output index—which is a physical index—has been related to an index of wages and salaries based on gross amounts paid out, uncorrected for fluctuations in the value of money. One would therefore expect the real cost of wages and salaries per unit of output to be substantially lower than is shown.

The biggest increases in wages and salaries have been in manufacturing industry (60 per cent. over the 7-year period), and in electricity, gas and water (62 per cent.), which have also registered the biggest increases in output (33 per cent. and 42 per cent. respectively). Increases in labour costs per unit of output have in fact been much lower in these two industries (20 and 15 per cent. respectively) than in any other, the highest being in distribution (40 per cent.), in building and contracting (32 per cent.) and in mining and quarrying (30 per cent.). The figures for manufacturing industry suggest that the more efficient firms must have avoided any increase in their labour costs per unit of output—some are known to have reduced them. There is doubtless much room for improvement in the distributive trades, as well as in the building trades and coalmining.

Significantly perhaps, the *Financial Times* stated in a leading article on August 19, that " there is no doubt that the United Kingdom can afford wages which are nearer to American levels than at present," going on to say that British organised labour must make this possible by adopting the attitude to productivity characteristic of the unions in the U.S. The argument is a simple and appealing one: more wages, therefore more purchasing power and through this more output, hence lower unit costs and improved competitive position overseas. But it can only be valid if efficient management and hard work bring down costs per unit of output, and if workers save and invest some of their earnings.

BLOODSHED IN FRENCH SHIPYARDS

Industrial unrest is mounting on the Continent. In France last week there was serious rioting in the shipbuilding towns of St. Nazaire and Nantes, where shipbuilding and engineering workers are seeking a flat all-round increase of 25 per cent. in their wages. Over 130 people were injured and one workman was killed. At Nantes the employers were forced under constraint to sign an agreement conceding the increase but immediately repudiated this and enforced a lock-out, affecting some 10,000 workers. This violence would have been deplorable enough in isolation, but there are indications that it is spreading to other shipyards—at Rouen, Le Havre and Dunkirk—and to other industries. The workers have no confidence either in their employers or in the arbitration machinery set up last May.

The trouble began in St. Nazaire, where the shipyards were destroyed during the war and did not start operating again until 1950, and then at wage levels which lagged far behind those paid to engineering workers in other parts of the country. After some initial violence they were granted a 22 per cent. increase. At Nantes, the employers refused to grant more than half the men's demands and the negotiations were broken off. All unions, whether right or left wing, are united in pressing their claim and there is little likelihood of a quick resumption of work unless the Government intervene. The French authorities are apprehensive that to grant the increases would touch off a country-wide wages spiral which would put an end to the stability of prices which France has had for the past 2 to 3 years. Meanwhile the deadlock continues, and with it the danger of more bloodshed.

A FIVE-DAY WEEK IN SHOPS ?

Retail shops are finding it increasingly difficult to retain and recruit labour, particularly men, and there have been several suggestions recently that the establishment of a five-day working week might solve the problem. The suggestion was first made by Mr. T. A. Bowen, chairman of the Barker group of department stores, that shops should be closed Sunday and Monday. He pointed out that Monday closing had worked well in Paris for many years and that he saw no reason why it should not work equally well in London. Mr. S. H. Leake, chairman of Selfridges, and Mr. J. Spedan Lewis, chairman of the John Lewis Partnership, were quick to point out that the sales of central London stores were higher on Monday than on Saturday morning and that they would therefore prefer to close all day Saturday. On the other hand, suburban and provincial shops would find Saturday closing quite impossible since most of them do at least one third of their trade on that day. The Grocers' Federation consider a five-day week " impracticable " and the National Chamber of Trades—representing some 300,000 shopkeepers—did not greet the suggestion with enthusiasm. Reactions from the Union of Shop, Distributive and Allied Workers were mixed: the five-day week has been an objective for many years, but most of the thinking has been on the lines of Saturday and Sunday closing.

The problem of the shortage of labour in the retail trade is, of course, part of the wider context of over-full employment. The hours worked and the pay do not compare vary favourably with manufacturing industry, and the Unions may well consider that the best way to arrest the labour wastage is to increase wages. (Increases ranging from 16*s*. to 21*s*. for women and from 10*s*. to 16*s*. for men have been mentioned.) To have to pay their workers more would certainly be an incentive to shop managements to introduce labour-saving methods. The wider introduction of self-service, of supermarkets and more efficient management might well achieve economies which could make possible the working of staggered hours and a six-day week, with closing hours pushed back to 8 or 9 o'clock, thus contributing to the convenience of shoppers and easing the pressure on staffs on Thursdays and Saturdays. The best solution therefore, may well be substantially higher wages, better equipment and organisation.

UNREST IN YORKSHIRE PITS

There is a deep sense of injustice among the 140,000 miners in Britain's largest coalfield, and passions are running high. Mr. Alwyn Machen, president of the Yorkshire and of the National Union of Mineworkers issued last week a strongly-worded public warning, leaving no room for doubt that strike action is contemplated. The dispute, which involves about 35,000 coal-face contract workers, has its origins in the area-wide strike which took place last May in support of a pay claim by fillers, was then described as " the result of years of delay in improving the price lists for contract workers " by Mr. John Hughes, of the Department of Extramural Studies, University of Sheffield, in a letter to *The Times*. During that strike the National Coal Board gave an assurance that a complete revision of price lists would be made, but so far only the fillers have had their position improved. Mr. Machen complained that pit managements appear afraid to give reasonable settlements and that other coal-face workers, including cutters, rippers, packers and the men who move the conveyors " are completly dissatisfied and leaving work, possibly going out of the industry altogether." Mr. G. W. Huckerby, chairman of the Doncaster Panel of Pits (which was in the forefront of the fillers' strike) said: " I think these people are the worst treated in the industry, and we will go to any length to secure justice for them."

Obviously, the N.C.B. gave their assurance under pressure, but once given it is difficult to understand why no action has been taken. The miners' leaders appear to be on firm ground when they complain of recalcitrance and dilatoriness on the part of pit managements. There is in Yorkshire a tradition of bad labour relations and extremism in union leadership, with greater readiness to strike than exists in other areas. Clearly, the N.C.B. should heed the warning of the Fleck Committee, that labour relations and personnel matters are not properly handled: " Most Colliery Managers have grown up with the troubles that beset the industry and with the organisation as they found it at the pit; they cannot conceive that things should be otherwise. The Colliery Manager has been taught how to mine but not how to manage. And he is expected to do too much unaided." The Committee's recommendation, that administrative and personnel officers " of suitable calibre " should be appointed, may go far to provide a solution to the problems of the Yorkshire area.

STOPPAGES AT EARL'S COURT AND ELSTREE

Last week, the Electrical Trades Union were involved in two lightning strikes. At Elstree, they and 500 members of the National Association of Theatrical and Kinematograph Employees staged a one-day strike to draw attention to what they regard as unreasonable delays in dealing with their claim for a 15 per cent. increase in wages. At Earl's Court they led a stoppage to secure, first, that E.T.U. members working on the preparations for the National Radio Show should be paid an extra 5*s*. a day expenses allowance and, second, that only members of trade unions affiliated to the T.U.C. should be allowed to work on the exhibition site. The show, which is a joint venture of the Radio Industry Council and the B.B.C., seems likely to be seriously delayed or even abandoned.

The B.B.C. are employing some of their salaried staff on installing television and sound equipment and have refused to enforce them, as requested by the E.T.U., to join a trade union. They will not compromise on what they regard as a most important principle: the right of a man to belong to what union he chooses or not to belong to a union at all. There the matter rests.

NEW MOVES BY RAILWAYMEN

The past week has been one of considerable activity for the three main railway unions, the N.U.R., A.S.L.E.F. and T.S.S.A. A great effort is being made by the N.U.R. leaders to secure a united front to face what their organ, the *Railway Review*, describes as " a grim fight ahead." They have invited the other two railway unions and also the Confederation of Shipbuilding and Engineering Unions to discuss a claim on behalf of railway engineering workers.

The prospect of agreement being reached between the three railway unions does not seem too good. A.S.L.E.F. leaders consider they were let down by the N.U.R. during their strike earlier this summer, and they appear keener to secure improvements in conditions of service than in putting forward a new claim for a wage increase. Last week A.S.L.E.F. announced that they have submitted to the Railway Staff National Conference a four-point demand for better working conditions which includes the full implementation of the 44-hour week, payment of wages while absent from duty owing to illness or accident, the removal of certain anomalies in mileage payments, and the extension of night-duty payment to operate from 6 p.m. instead of from 10 p.m.

The N.U.R. executive were instructed to claim for more pay as soon as possible by their general meeting at Hastings last month, and also to seek better relations with the other unions. Action in these matters cannot therefore be long delayed. While unity would have some real advantages for them, A.S.L.E.F. and T.S.S.A. may fear that if they agree to co-operate too closely they will in fact become integrated into a single large industrial union under N.U.R. leadership. But, more than this, the tradition of rivalry and past differences may keep the three unions apart.